Laboratory Exercises

in

Chemistry 30

DEPARTMENT OF EDUCATION
SCHOOL BOOK BRANCH
EDMONTON - ALBERTA

Laboratory Exercises

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CONTENTS

N.B. The year's work consists of a minimum of 15 experiments. As pupil work, do the ten experiments as marked with an asterisk as well as any five others. If time permits do more.

PREFACE

The experiments set forth in this manual were selected for and parallel the problem arrangement of *Chemistry for Secondary Schools* (Advanced Edition). In recognition of the different conditions under which teachers of high school chemistry work, and of the varying nature of pupils of the subject, two general types of experiments have been included: (a) those that deal primarily with the development of fundamental facts, concepts, generalizations, principles and laws of chemistry; (b) those that relate primarily to the applications of these fundamentals.

No experiments have been included which require costly apparatus or materials. Some of the experiments are too long to be completed by the average student in a single laboratory period. Usually in such cases some parts of the experiment may be omitted without at all affecting the remainder, or the whole experiment may be divided and completed at a later session. Some teachers may wish to use some parts as demonstrations or may assign parts to different students or to groups of students. The parts as set up for demonstration are, in general, for the teacher simply because **there is a risk** to the uninitiated or the apparatus is not in quantity in the ordinary high school laboratory.

Whenever possible individual laboratory work should be made the foundation of the beginning course in chemistry. It should be well supervised and carefully directed so that it will be a thoughtful and an enthusiastic learning procedure for the student, not merely an exercise in manipulating apparatus and following directions. Questions are liberally sprinkled through the experiments to keep the student in an enquiring frame of mind and to make sure the salient points are not lost. They also provide an opportunity for reflective thinking, or the scientific method. In the laboratory use your mind as well as your hands. Concentrate on your work. Form the habit of asking yourself why you are doing each part and what your results mean.

The appendix has the regular list of equipment required as well as the chemicals. A very important addition is a list of liquid reagents. This list shows how to make them and in these **concentrations they will give better results.**

The four chapters, "Carbon and Its Compounds", "Fuels and Flames", "Sulphur and Its Compounds" and "Salt and Its Place in Industry" are not to be dealt with in too much detail; the experiments are set up as teacher demonstration simply because the ground may thus be covered more quickly. This does not mean the student may not do all or some of the parts.

DIRECTIONS TO STUDENTS

1. Before coming into the laboratory to perform an experiment, study the directions outlined in the procedure. Be sure that you understand what you will be doing, and why. Do not attempt an experiment the relevant theory of which you have not already studied.

2. Question each step as you proceed. Learn the names of the chemicals and apparatus. Examine materials used; and also the precipitates formed, and other products, so as to be able to identify them as your work progresses.

3. Follow the directions closely and use great care when flames, acids, bases, or inflammable liquids are employed.

4. Use small quantities of chemicals. Larger quantities frequently retard the progress of the experiment.

5. Record all results of your experiment and make liberal use of diagrams (sectional) in making your report. These diagrams should be neatly drawn and neatly labelled.

6. Be sure your apparatus is clean. After completion of the experiment, clean all apparatus and leave the desk in a dry and tidy condition.

7. Learn the capacity (in cc.) of an ordinary test tube so as to be able to measure out approximate volumes (10 cc.) without loss of time.

8. In case of accident, call your instructor at once.

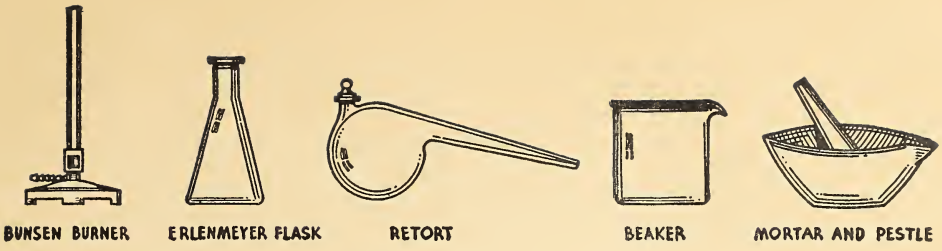
In the following exercises:

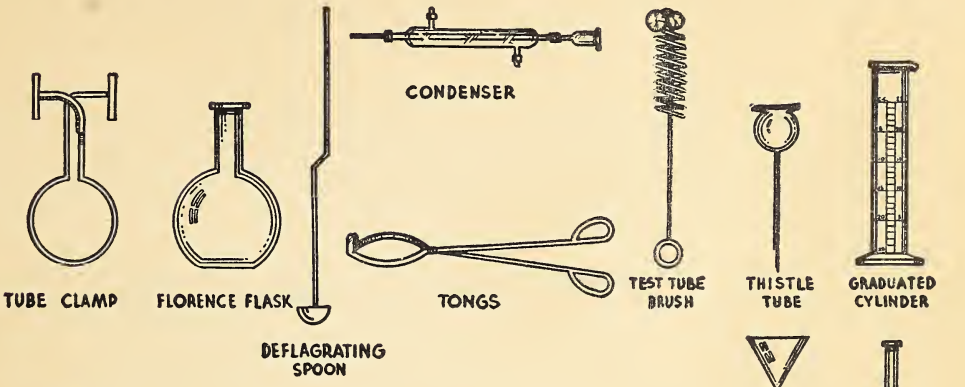
"Result?" means to make a written record of your observation.

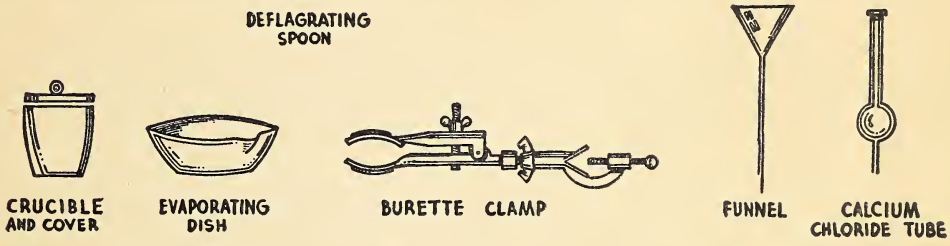
Interpret "Odor?" "Equation?" also in written form.

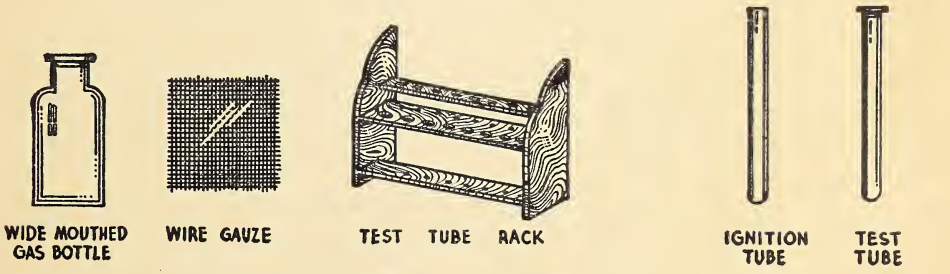
Unless the word "dilute" is used before an acid, the concentrated acid is to be used.

Bracketed numbers refer to related material in the authorized textbook.


BUNSEN BURNER
ERLENMEYER FLASK
RETORT
BEAKER
MORTAR AND PESTLE


TUBE CLAMP
FLORENCE FLASK
DEFLAGRATING SPOON
CONDENSER
TONGS
TEST TUBE BRUSH
THISTLE TUBE
GRADUATED CYLINDER


CRUCIBLE AND COVER
EVAPORATING DISH
BURETTE CLAMP
FUNNEL
CALCIUM CHLORIDE TUBE


WIDE MOUTHED GAS BOTTLE
WIRE GAUZE
TEST TUBE RACK
IGNITION TUBE
TEST TUBE
TEST TUBE HOLDER


GLASS PLATE
TRIANGLE
WATCH GLASS
BLOW PIPE

SOME SIMPLE OPERATIONS

1. Pouring from bottle to test tube: Hold the bottle in the right hand, and the test tube with the thumb and fore-finger of the left. Grip the stopper between the remaining fingers of the left hand and the palm. When pouring let the mouth of the bottle rest gently against the tube thus avoiding drops of the liquid running down the outside of the bottle. The point here is that the stopper of the bottle should not be laid down on the bench——mixed stoppers?

2. Other cases of pouring: When pouring a liquid from one bottle to another a glass rod is generally used. Hold the rod tightly against the lip of the vessel to prevent the trickling of the liquid down the outside. This saves labels, benches, and fingers.

3. Boiling a liquid in a test tube: The common trouble here is heating the bottom of the tube. This causes the vapor formed inside the liquide to violently eject some or all the liquid. This tendency is reduced if the liquid is heated near the surface. Avoid large quantities (a third of a test tube is quite enough). Avoid continual shaking with a rapid wrist movement. Never point the test tube towards yourself nor anyone else. Do not heat the test tube above the liquid level as it will very likely crack.

4. Boiling liquid in a beaker or flask: Use a wire gauze and a ring stand. Do not let the flame get above the liquid as the flask may crack. If there is a large amount of solid matter heat carefully and stir frequently.

5. Decanting: Decanting is a method of washing an insoluble substance. Make the liquid swirl around a few times, then let it settle and pour off the water. Repeat several times to remove any soluble impurities and any light insoluble ones. Many powders, precipitates, etc., settle quite easily after the liquid in which they are suspended has been boiled.

6. Filtering: Like decanting, filtering is used to separate an insoluble solid from a liquid. Fold a filter paper exactly in half and fold again into quarters, pressing the creases, and open into a cone shape. Place this in a funnel and let a little water drop on it to help it grip. Press the paper gently against the glass. A hot liquid filters faster than a cold one. The more closely the filter paper fits, the more rapidly will it do its work. Do not try to stir anything on the filter paper as it tears easily.

7. Evaporating: Use an evaporating dish and wire gauze. Boil rapidly until most of the water has been driven off. Lower the flame. When the water has been driven off the wet salt will begin to "spit". Heat carefully and gently. If one needs all the salt, then finish the evaporating by means of a water-bath by allowing the dish to set in a hot water bath which is gently boiling.

Before you start an experiment, study it carefully. Take a few notes. Use the laboratory manual during the experiment only as a reference or guide, not as a "cookbook". Students who never read an experiment before beginning to perform it or who must keep their eyes on the book waste time, lose interest, and are not free to observe and learn.

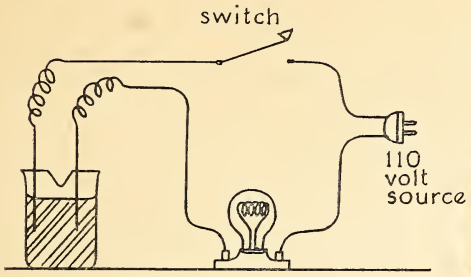
BE CAREFUL! Most accidents are due to carelessness. If you are alert and follow instructions, there should be no cause for any accidents.

IONIZATION AND THE ELECTRON THEORY

Demonstration 1

Laboratory Exercise 1

Reference: Text, Chapter 16, Pages 153-163.



Parts 1 to 5 for demonstration.

1. Arrange the apparatus as shown. Arrhenius determined the apparent percentage of dissociation of many compounds by an electric current. The bulb placed in series with the solution to be tested will indicate whether or not electricity is passing through the various substances to be tested. The brightness of the lamp will indicate the degree of conductivity and hence the percentage dissociation. The electrodes (the bare ends of a heavy copper wire) are to be washed and dried between each experiment. Use some distilled water and try to pass the electric current through it. Result? Why? Now, on a board, place the terminals in some dry NaCl. Result? Why? Keeping the electrodes in the dry salt add a little of the distilled water. Result now? Why the difference? Equation? Scrape into a beaker and add 100 cc. water. Result now? Fill the 500 cc. beaker with more water. Why is the light now so bright? Repeat using other dry salts, glacial acetic acid, or concentrated sulphuric acid. Account for the results.

2. Apparatus as before. Place 3N (what is a three normal solution? Manual page 69) of HCl, H_2SO_4, H_3PO_4, and $HC_2H_3O_2$ in the beaker in turn. Test the conductivity of these solutions in quick succession. Results? Why? What is a strong acid? List three.

3. Repeat using 3N solutions of KOH, NaOH, NH_4OH. Results? Why? What is a strong base? Relation to the Activity Series? (Text: 45, 283).

4. Repeat, using $NH_4C_2H_3O_2$, NaCl, $Pb(C_2H_3O_2)_2$. Results? Why?

5. In separate test glasses place 100 ml. of a 1N (Does this mean **in**?) solution of HCl, H_3PO_4, and $HC_2H_3O_2$. To each add 5 ml. methyl violet indicator and place a white background behind the containers. The different colors show a different concentration of the hydrogen ion. HCl will be yellow, H_3PO_4 a yellow-green and the $HC_2H_3O_2$ will be blue). Hydrion pH papers prove very interesting.

6. **Dissociation in relation to reaction:** (a) Add concentrated sulphuric acid to a piece of zinc in a test tube. Result? Why? Repeat using a dilute solution (1 volume of acid to three volumes of water. Acid to water **or** water to acid? Which? Why? **CARE!** Text, pages 46, 206.) Result now? Why? (b) Mix on a paper a pinch of dry potassium iodide with an equal amount of dry lead acetate. Result? Now use a dilute solution of the same salts. Compare results. Why the difference?

7. **Colors of salt solutions:** The color of a dilute solution (aqueous) of an electrolyte is an additive effect of the color of the anions, the cations, and the un-ionized molecules. The color of the latter may be quite different from the color of the two former, so that the color changes as the solution is made more and more dilute. Among the colored ions copper is blue, Cu^{++}; Fe^{++}, Ni^{++}, Cr^{+++}, MnO_4^{--} ions are green; Co^{++} is red; Mn^{++} a pale pink; MnO_4^- is a purple; CrO_4^{--} is yellow, and Fe^{+++} is brownish red. The colorless ions include Cl^-, I^-, Br^-, NO_3^-, PO_4^{---}, ClO_3^-, K^+, Na^+, Ca^{++}, Mg^{++}, Pb^{++}.

Into each of three dry test tubes put a small quantity (1 cc.) of copper sulphate, copper chloride, and copper bromide. Observe carefully the color changes as you add TWO DROPS of water and then slowly add more water until no further change occurs. The final color is a light blue in all cases. Tabulate your results as follows:

Salt	Formula	Color when it is			
		dry	moist	concentrated	dilute
copper sulphate					
copper bromide					
copper chloride					

THE LABORATORY REPORT

Regardless of what form the report takes it is imperative to "write up" the report immediately while the details are still fresh in your mind. It is strongly suggested that you make short notes as the experiment progresses and with the aid of the text and reference books make out the report as fully and accurately as possible. **Wherever possible use an equation.**

Never go into the lab. "cold" and expect to learn much from the experiment. You should become familiar with the background of the experiment by a careful study of the exercise beforehand.

The laboratory work gives reality to Chemistry by presenting sensory experiences which aid in grasping important ideas. It makes fundamental principles a part of your experiences and hence more meaningful.

The next page shows a suggested form for the laboratory report.

Name ..... | Course .....

Room ..... | Period No. .....

Teacher ..... | Mark .....

Aim: .....

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Apparatus & Material	Sectional Diagram
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Theory:

Procedure:

Observations:

ACIDS; BASES; SALTS

Laboratory Exercise 2

Reference: Text, Chapter 16, pages 153-163

A. Acids

Prepare a dilute solution of each of the following acids by adding 2 or 3 drops of the concentrated acid to 10 cc. of water in a test tube and mix thoroughly: hydrochloric, sulphuric, nitric, phosphoric, acetic. With each solution carry out the following steps:

1. Taste **one drop** of the dilute solution. (Rinse the mouth with water).

2. By means of a clean glass rod transfer **a drop** of each of the dilute solutions to a piece of blue litmus paper. Repeat using red litmus paper and note the results. (One piece should do 4 or 5 tests.)

3. Feel between the thumb and finger any one of the above solutions. Notice how it "grips".

4. To one of the acids add a few drops of litmus solution. To another add a few drops of pink phenolphthalein solution. To the third add a few drops of methyl orange. Note the results in each case.

5. To a little of the acid add a pinch of baking soda and note any reaction. Equation? Dip a clean glass rod in limewater and lower the rod with its attendant drop into the mouth of the test tube and observe any change in the limewater. Equation? Try various acids.

6. Add a pinch of magnesium powder or some magnesium ribbon to some of the dilute acid and note any reaction. Equation? Lower a blazing splint into the test tube and describe the results. Equation?

7. Compare the formulas of the acids. In what respect are the acids similar in composition? List the properties that are common (Text, page 157.)

8. Compare the degree of action. Why the difference? Strong and weak acids. List.

B. Bases

Repeat the parts as outlined above on a solution of each of the following bases: sodium hydroxide, potassium hydroxide, calcium hydroxide, and ammonium hydroxide. List the common properties (Text, page 158.) Strong and weak bases. List.

C. Salts

Dilute 5 cc. of the ordinary laboratory solution of sodium hydroxide (1 part of the hydroxide by weight to 10 parts of water) with an equal volume of water. Add a few drops of phenolphthalein. Add 4 or 5 drops of any ordinary concentrated acid e.g. HCl. Stir the resulting solution with a glass rod. Is the solution still basic? Now continue to add the acid **drop by drop** until the resulting solution is neutral. Equation? Pour the solution into an evaporating dish and heat to dryness. What are the crystals? Taste. Equation? What is the name given to a compound formed by the action of acids and bases? Any heat generated during the process of neutralization? Number of calories? What are the other methods of salt preparation? (Text, page 161.)

IF TIME PERMITS you could devise experiments for the various methods of salt preparation and then do them. Check with your teacher before you start.

Substance	Feel	Taste	Color of phenol-phthalein	Color of litmus	Color of methyl orange	Baking soda	ribbon Magnesium	Ions in solution
hydrochloric acid								
sulphuric acid								
nitric acid								
phosphoric acid								
acetic acid								
sodium hydroxide								
potassium hydroxide								
calcium hydroxide								
ammonium hydroxide								

NEUTRALIZATION

Laboratory Exercise 3

Reference: Text, Chapter 16, pages 153-163.

VOLUME OF ACID TIMES ITS NORMALITY **EQUALS** VOLUME OF BASE TIMES ITS NORMALITY.

$$Va \times Na = Vb \times Nb$$

$$20 \times 2 = Vb \times 1.5$$

$$Vb = 26.66 \text{ cc.}$$

20 cc. of a 2N solution of HCl is titrated against a 1.5N solution of NaOH until the point of neutralization is reached. What volume of NaOH is required?

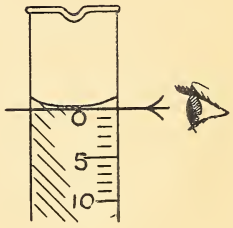
When a neutralization is carried out in a quantitative way the procedure is called titration (Text, page 162).

A normal solution of an acid contains 1 gm. hydrogen ions per litre of solution. (Manual, page 69.)

A normal solution of a base contains 17 gm. of hydroxyl ions per litre of solution.

Any volume of normal hydrochloric acid will neutralize an equal volume of normal sodium hydroxide solution.

This principle that normal solutions are equivalent to one another, volume for volume, is a very important one to grasp.



1. Wash out a burette and then rinse it with a little of the solution of sodium hydroxide provided. It contains 40 gm. NaOH per litre of solution. Molarity? Normality? Why? Using a funnel fill the burette above the zero mark (Why?) and run out a little so as to fill the part below the tap (Why?). Turn the stopcock and let the solution **slowly** flow out until the bottom of the meniscus (see diagram) of the liquid in the burette is on the level of the zero mark. In a similar way fill a second burette with the acid solution given. You do not know the strength of this solution. Find it as shown in part 2 below.

2. Let exactly 15 cc. (or any other amount) of the acid solution flow into a 100 cc. beaker and add a few drops of phenolphthalein solution. Run in 2 or 3 cc. of the hydroxide solution. Place the beaker on a sheet of white paper. Notice that where the liquids come in contact there is a reddish color produced which disappears quickly on stirring (use a whirling motion). Run in more of the solution, a little at a time, until the color fades slowly, and then a drop at a time — stirring meanwhile—until the entire liquid remains colored FAINTLY pink. This marks the end point or the approximate point of neutralization. Record the number of cc. used. Calculate as shown above. Set up a table to record your results. Take an average of three runs.

3. In the above parts calculate the number of grams of HCl required to make up a solution of the strength shown by your work in part 2.

4. If a solution of dilute H_2SO_4 is 5N calculate the weight used in 100 cc. of the solution. (24.5 gm.)

5. What volume of 5N H_2SO_4 would be required to neutralize 120 cc. of a normal KOH solution? (24 cc.)

6. Suppose you had 750 cc. of dilute nitric acid of such strength that 25 cc. of it was neutralized by 30 cc. of a normal NaOH solution. How much water would you have to add to it in order to reduce it to normal strength? (150 cc.)

7. Find the normality of some "Perfex" or "Javex" or some other bleach.

HYDROLYSIS

(Hydrolysis is the opposite process to neutralization. Here a salt and water give an acid and a base.)

Laboratory Exercise 4

Reference: Text, Chapter 16, pages 153-163.

$$ZnSO_4 \rightleftharpoons Zn^{++} + SO_4^{--}$$
$$+ \qquad +$$
$$2H_2O \rightleftharpoons 2OH^- + 2H^+$$
$$\downarrow \qquad \downarrow$$
$$Zn(OH)_2 \qquad H_2SO_4$$

A water solution of zinc sulphate turns blue litmus paper red. The OH^- have been withdrawn from the solution to form the molecules of zinc hydroxide thus leaving an excess of H^+ in the solution.

Type 1	Na_2CO_3	Sb.Wa
Type 2	$CuSO_4$	Wb.Sa
Type 3	NaCl	Sb.Sa*
Type 4	NH_4CN	Wb.Wa

The "Sb" means that the cation is the strong base forming type. What other ions could one use in place of the sodium ion?

The "Wa" means an anion from a weak acid.

*Type 3, a salt formed by the ions of a strong base and the acid radical from a strong acid, is considered to have no practical hydrolysis.

1. Place a small quantity of each of the salts listed below in separate clean test tubes. With a clean stirring rod place a drop of each of the solutions on both red and blue litmus paper. One strip of paper should test 4 or 5 solutions (Be sure to rinse the stirring rod every time). Sodium chloride, ferric chloride, copper sulphate, sodium carbonate, potassium nitrate, ammonium sulphate, sodium borate (borax), sodium sulphate. Tabulate your results as shown below:

Name of salt	Formula of salt	Formula of base derived	Formula of acid derived	Effect on litmus	Acid, base or neutral reaction	H^+ conc. high or low	OH^- conc. high or low	Salt of
sodium carbonate	Na_2CO_3	NaOH	H_2CO_3	red to blue	base	low	high	Sb.Wa

2. List the strong acids and weak acids: the strong bases and weak bases. Why are some strong and others weak? What is the relation of strong base and E.M.S.?

3. Write equations for each of the reactions in part 1 above.

4. Write IONIC hydrolysis equations for any three of the above reactions in the same way as the hydrolysis of zinc sulphate shown. Watch for the position of the heavy arrow. What does it mean?

5. Merely by **looking** at these formulae tell whether they will test acidic, basic or neutral: $LiBr_2$, $AlCl_3$, K_2CO_3, $FePO_4$, Na_3PO_4.

Can you make up a general statement covering ALL the cases of this experiment? Has the Activity Table (Text, pages 45, 283) any relation to the problem?

REVERSIBLE REACTION; COMMON ION EFFECT; EFFLORESCENCE AND DELIQUESCENCE

Demonstration 2

Laboratory Exercise 5

A. Reversible Reaction.

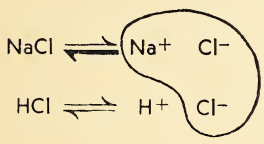
To a solution of sodium carbonate add some potassium nitrate solution. Is there any reaction? Explain. Write both molecular and ionic equations. If you evaporated the solution to dryness how many kinds of molecules would there be? What is NOT formed? Why do reactions go to completion (3 reasons)?

Into a beaker put a small quantity (1 grain) of bismuth trichloride. Add a drop or two of hydrochloric acid and if necessary just a little more to dissolve the salt. Add water slowly, stirring constantly, until a definite change occurs. Result? The equation representing this reaction is: $BiCl_3 + H_2O \rightleftharpoons BiOCl + 2HCl$. The bismuth oxychloride is insoluble.

Now add dilute hydrochloric acid until the reaction is reversed. With care an end point may be reached where one drop will throw the reaction to the left or to the right depending on whether it is HCl or H_2O. Try it.

B. Common Ion Effect (Demonstration)

Make a saturated solution of sodium chloride in a beaker. Be sure it is a good strong solution (Text, Chapter 8). Now add some hydrochloric acid. The Cl^- is the common ion. Why this term?



If the concentration of the chlorine ion increases, then the concentration of the Na must decrease. The only way to do this is by the removal of NaCl molecules.

Did you get a "snow" on the addition of the HCl? Try again but this time use barium chloride solution in place of the sodium chloride.

C. Efflorescence.

There are hydrates that hold their water of hydration (crystallization) so loosely that on exposure to air they will lose their crystal form and crumble into a white powder, their anhydrous form. Place some washing soda crystals in an evaporating dish and leave exposed over night. Do the same with "hypo" crystals. Result? Why? Equations? If the atmosphere is very dry try also some bluestone. What happens if bluestone crystals are gently heated. Devise an experiment using a balance, sand, two watchglasses, and some sodium sulphate (Glauber's salt).

D. Deliquescence.

There are some solids that are very soluble. Calcium chloride absorbs moisture from the air. Why do they use it on a gravel road? Substances that form solutions when exposed to air are said to be deliquescent. They make good drying agents and are used to remove moisture from gases. On a watch glass place a few pellets of sodium hydroxide. Counterbalance with dry fine sand. Allow to stand over night. Why the result? Why put concentrated sulphuric acid in an open dish and leave in a balance case?

COMMON FORMS OF CARBON; DESTRUCTIVE DISTILLATION; USES OF CARBON; CARBON DIOXIDE; FIRE EXTINGUISHER; CARBON MONOXIDE

Demonstration 3

Laboratory Exercise 6

Reference: Text, Chapter 17, pages 164-184 (see note in Preface)

A. Forms of Carbon (Text, pages 164-172)

1. Examine each of the forms listed: diamond, graphite, wood charcoal, soft coal, hard coal, coke, boneblack, lampblack and carbon black. Note the "feel" of each. Try to mark a piece of paper with each. What is the color of each? What of the hardness of each? Heat a small piece of graphite as strongly as possible. Result? Suggested use of graphite. How much lead is there in a lead pencil. Discuss.

2. Use two or three of the following (wood, paper, sugar, wool, bread, potato, carrot, corn starch, paraffin wax, meat, cotton) and experiment as suggested. Cover the bottom of a small crucible with clean sand and place one of the samples on it. Cover. Heat strongly for about five minutes. Cool and examine the contents. What changes have taken place? What is common to all the experiments? Place the residue in a clean evaporating dish and heat strongly without the cover, Describe and account for the result.

3. Close the air inlet of a lighted Bunsen burner and shut down the gas until the flame is very small. Hold a sheet of glass in the tip of the flame. Result? Why? Hold the other corner of the glass in the flame of a paraffin candle. Result? Why? Compare the two results. Place two cc. of kerosene in an evaporating dish and ignite it. Hold the third corner of the glass plate in the flame. Result? Why? What is the color of the flame in each case? Have you ever seen the flare at an oil well? (Text, page 189). Account for the presence of carbon in each of the above.

B. Destructive Distillation (Demonstration by groups)

1. **Wood.** Use the apparatus as shown on page 168, Text. Use wood shavings or splints. Heat with a moderate flame. Watch carefully for changes within the tube. Light the jet when you see substances gathering in the bottom of the vertical tube. What are the three types of substances resulting from this destructive distillation? Just what does this term mean? (Text, page 168). Name the six substances formed. Test the distillate (meaning?) with litmus. Note odor, color and feel of the distillate.

2. **Coal.** Use the same apparatus but this time use soft coal. Heat moderately. Hold pieces of moist litmus paper in the jet. Result? Why? When substances form in the vertical tube light the jet. Note the flame as to size, duration and color. What are the three types of products resulting from the destructive distillation. When cool, examine the residue. Note the odor, color and feel of the distillate. Study the coal products tree on page 170, Text.

C. Uses of Carbon

1. In 100 ml. of water dissolve a teaspoonful of brown sugar. Note the color. Now add two teaspoonfuls of boneblack and boil for five minutes. Filter. Color of filtrate? Why? Allow 2 ml. to stand on a watch-glass until next period. What is the residue?

2. In a test tube one-quarter filled with activated carbon add a dilute solution of potassium permanganate. Shake well and filter. Why the change in color?

3. Explain the action of activated carbon in the canister of a gas mask. (Text, page 169). Why is activated charcoal more efficient than any other form of carbon? What is **ad**sorption?

4. (Demonstration) Pour mercury to a depth of approximately one inch in a 250 ml. beaker. Fill a test tube with ammonia gas (Text 248), insert a piece of wood charcoal into the test tube and invert it in the mercury. Clamp the test tube in a vertical position and observe any change in the mercury level. Describe and account for the change in the mercury level. (Text, 169).

5. To 5 gm. of copper oxide add an equal volume of powdered charcoal. Mix thoroughly and place in a test tube with a one-holed rubber stopper and delivery tube which dips into 10 cc. of limewater in a second test tube. Heat strongly for about ten minutes. Observe each tube carefully and account for the results. What is a reducing agent? Compare with set-up on page 51 of text. When cool, empty the test tube into an evaporating dish. Examine carefully and then add some concentrated nitric acid. Describe and account for the reaction (Text, pages 256-257).

6. Carve out a small cavity (by rotating a dime) in a charcoal block. Place a little litharge (PbO) or some other oxide of lead in the cavity. Using a blowpipe, heat the PbO in contact with the charcoal (carbon) until a metallic globule appears. Equation. Reduction? Other reducing agents?

D. Carbon Dioxide (Text, pages 172-178)

1. Lower a glowing piece of charcoal into a jar of oxygen which has one-quarter of an inch of limewater in it. After the action ceases, remove the charcoal and shake the bottle. Account for the behavior of the charcoal and for the change in the limewater. Write equations for all reactions.

2. Lower a burning candle into a large jar which has some limewater in it. After a few minutes remove the candle and shake the bottle. Account for the behavior of the candle and for the change in the limewater. Equation?

3. Put some magnesium carbonate in a test tube fitted with a one-holed stopper and delivery tube which dips into a second tube containing 10 cc. limewater. Heat the first test tube and account for the change in the limewater. Equations? (Manual, page 59.)

4. Use any of the following—magnesium carbonate, sodium carbonate or sodium bicarbonate with any of these dilute acids: nitric, hydrochloric, sulphuric or acetic. Equations? Is carbon dioxide given off in each case? Reaction with limewater? Generalization?

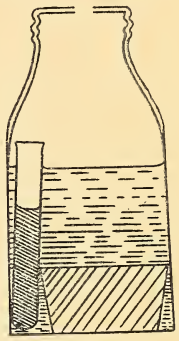
5. Blow your breath through 10 cc. of limewater in a test tube. If you continue to blow for some time what further change takes place? Write the two equations, showing the formation of the carbonate and then the bicarbonate.

6. Test for carbon dioxide in the air by placing a little limewater in a watch-glass and leave until next period.

7. **Prepare carbon dioxide and study its properties** (Set up apparatus as on page 173 of text.) Collect 4 bottles of the gas. Note the color and odor. Lower a burning splint into a bottle. Does it support combustion? Wind a 6" strip of magnesium ribbon in a tight spiral, and holding it with a pair of tongs lower the burning magnesium into a jar of the gas. Describe the deposit formed. Equation? Does carbon dioxide support combustion? Light a short candle and place in a beaker. Pour the carbon dioxide from the third bottle into the beaker. What happens to the candle

flame? Why? Name two properties of carbon dioxide as shown by this experiment. To the fourth bottle of carbon dioxide add 15 ml. water. Place the palm of hand over the mouth of the bottle and shake. Test with litmus. Equation? Why the suction on the hand? What is an acid anhydride? One-third fill a test tube with limewater and pass carbon dioxide from the generator through it until the milkiness clears. Equations? Pour 25 ml. from a bottle of soda water into 10 ml. of limewater. Reaction? Why? Equation?

8. **Common fire extinguisher.** (Demonstration). Use a large-mouth bottle with vertical sides and a tight fitting screw cap with gasket. Punch a hole in the lid. Half fill a small test tube with concentrated sulphuric acid and wedge in place with a rubber stopper. Three-quarter fill the bottle with a concentrated solution of sodium bicarbonate. Screw cap on and invert the bottle **over the sink.** Describe the action of the soda-acid fire extinguisher (Text, page 176). Equation? Describe and account for the reaction. What three properties of carbon dioxide make it useful in extinguishing fires? Discuss the foam extinguisher used for oil fires.



Discuss the uses of carbon dioxide under these headings: soft drinks and Henry's law; carbon dioxide "snow"; "dry ice" for refrigeration especially in planes; leavening of dough in bread, etc.; baking powder; airport crash truck; liquid carbon dioxide for fire fighting; photosynthesis (Text, pages 165, 182).

E. Carbon Monoxide: To prepare, collect and study.

(**Care:** Because of the poisonous nature of carbon monoxide, care must be taken to prevent the escape of more than small amounts of this gas into the room.)

Apparatus set up as on page 178 in text. Warm the formic acid slightly and then let the concentrated sulphuric acid fall **one drop at a time.** Equation? What part does the sulphuric acid play? Collect one full bottle and one only one-third full. Set upright and cover with glass. Comment on the color, odor, solubility, density of the gas. Lower a lighted splint into the full bottle. Does the gas burn? Support combustion? Pour 20 ml. limewater into the bottle with the mixture of carbon dioxide and air. Shake. Result? Bring a lighted splint to the mouth of the bottle. Result? Again shake. Result now? Equation. Why is carbon monoxide so poisonous? Text, page 179. What is the difference between internal and external suffocation?

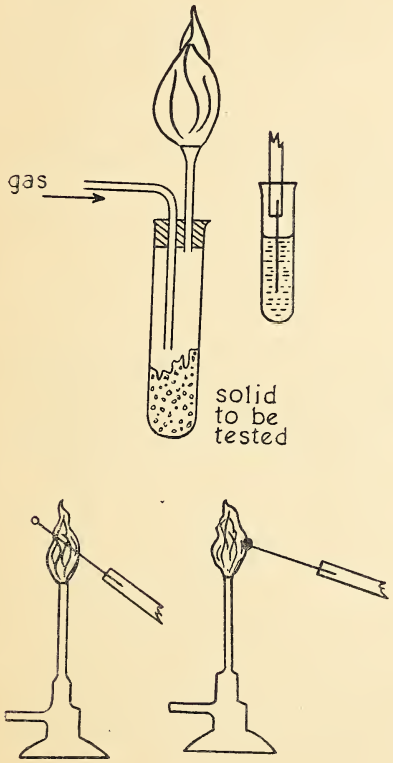
FLAME TESTS; FLAME STRUCTURE; COMBUSTION PRODUCTS; BORAX BEAD; COBALT NITRATE

Demonstration 4

Laboratory Exercise 7

Reference: Text, Chapter 18, pages 185-194, 287.

A. Flame Tests



(1) Use the apparatus as shown (if you have gas) and as a **teacher demonstration.** Place the salt to be tested in the bottom of a large test tube. The exit pipe is of glass or copper and flattened at the end to make a long slit. Make up 7 tubes as shown and keep. Adjust gas pressure to get a flame about two feet long. Tap the side of the tube. The gas drives some of the solid up into the flame. Here it ionizes and the metallic ion imparts to the flame a characteristic color. Use the following substances in the solid form: lithium nitrate, sodium carbonate, potassium carbonate, copper chloride, calcium sulphate, strontium nitrate, barium carbonate. Tabulate the colors imparted to the flame. (242, 244, 287.)

(2) **Use paper towels** soaked in the solutions of the above salts (one at a time) and note the color imparted to a flame.

(3) Use a platinum wire sealed in a glass rod. Clean the wire carefully by dipping it into dilute hydrochloric acid and then touching the **EDGE** of the flame. Adjust your Bunsen burner to a colorless flame. Repeat many times until no color shows. Now dip the clean wire into the solution to be tested. Note the color of the flame. Clean the wire as before. Now test the next solution. Use solutions of the substances tested in (1) above. Try to remember that the glass rod is merely a handle and is not dipped into the dilute acid nor is it rammed into the flame! Be careful.

(4) Adjust the air of a lighted Bunsen burner until a blue non-luminous flame is produced. Place a large asbestos pad under the burner. Sprinkle into the flame some of each of the following: sodium nitrate, potassium sulphate, calcium chloride powder, powdered charcoal, finely divided iron, zinc oxide. Record results. What is the difference between the first three and the last three? Why?

B. Flame Structure

Study text, pages 191-193. Adjust the air supply to produce a flame with a well-defined inner cone. Hold a very fine wire gauze horizontally in the flame just below the tip of the inner cone. Repeat using a piece of cardboard. When the cardboard begins to char, remove and examine. This time hold the cardboard vertically in the flame's center and allow the cardboard to rest on the burner. Remove and examine. Make diagrams of the charred portions. What do they tell you about the flame? Now hold a 6" piece of glass tubing with one end inside the inner cone. Light the open end. Result? Why? Insert a pin through a match as shown (Text, page 193). Turn on the gas and light the burner. Account for the behavior of the match. Hold a fine wire gauze an inch above the burner. Turn on the gas and light it ABOVE the gauze. What is the effect of the gauze on the flame? Why? Davy Safety Lamp? Bring a lighted match slowly

down to the wick of an unlighted candle. Watch carefully the manner in which the candle flame is produced. When the flame is well established blow it out and immediately bring a lighted match to the wick. Account for the action that takes place when the candle is relighted. What factors are necessary for the production of a flame?

C. Combustion Products

Fill a large flask with cold water. Be sure the outside of the glass is dry. Hold over the non-luminous flame of a burner. What is the liquid formed? Test with anhydrous copper sulphate. (Text, page 62). Rinse a beaker with limewater and hold inverted over a Bunsen flame, or a candle flame or burning kerosene. What is the effect on the limewater? (Text, page 175). Have you ever had to clean a lamp chimney? Where did the soot come from? Hold the corner of a sheet of glass in a candle flame. Result? Why?

D. Borax Bead Test

Use a platinum wire as before but bend the end into a small loop. Clean as before. Dip the hot wire into a little powdered borax and hold in the flame until the borax melts down to a clear glass. Repeat until you have a clear bead covering the loop. If the head is colored or "muddy", the wire is dirty. When you wish to remove the bead break it off the wire by tapping it on the base of a ring stand with a file.

After getting a clear bead, dip it into a little of the solution (or a very little solid) and re-heat in the flame until the material has dissolved in the bead. Remove and examine the color. Clean the wire and make a new clear bead for testing the next compound.

Try ferric chloride, cobalt nitrate, chromium sulphate, manganesse chloride, nickel nitrate and copper sulphate. RECORD IN TABULAR FORM YOUR OBSERVATIONS.

E. Cobalt Nitrate Test

Place a small amount of the material to be tested in a small depression in a charcoal block. Direct a flame onto the compound by meansof a blowpipe held near the upper part of a Bunsen burner flame. After the material is hot, add **two drops** of cobalt nitrate solution from a dropping bottle. Heat again in the blowpipe flame. Note the color of the residue after cooling. Make tests of compounds of magnesium, aluminum and zinc. RECORD IN TABULAR FORM YOUR OBSERVATIONS.

8

ALLOTROPIC FORMS OF SULPHUR; HYDROGEN SULPHIDE; SULPHUR DIOXIDE; SULPHURIC ACID

Demonstration 5

Laboratory Exercise 8

Reference: Text, Chapter 19, pages 195-210. (See note in Preface)

A. Sulphur and Its Allotropic Modifications { Rhombic; Prismatic, monoclinic; Plastic, amorphous

(1) Examine samples of roll sulphur and flowers of sulphur (Text, pages 197-199).

(2) Half fill a test tube with small lumps of roll sulphur. Heat slowly and carefully rotating the tube until all the sulphur has melted. Note the color and nature of the liquid.

(3) Pour the melted sulphur into a dry filter paper placed in a funnel. As it cools crystals will form and as they reach the center quickly pour the remaining molten sulphur into cold water; remove the filter paper and open out flat. Examine the crystals. Keep them for Parts 4 and 5.

(4) Place a few of the crystals from part (3) in a test tube and add a few ml. of carbon disulphide. (**Caution:** Keep flames away as carbon disulphide is quite volatile and very inflammable.) Shake. Do the crystals dissolve? Pour the solution on a watch glass. Allow to evaporate. Examine the crystals. Repeat, but this time use a small piece of roll sulphur. Results?

(5) Allow the remaining crystals on the filter paper to stand until next period. Any changes?

(6) Use the same test tube as you did in part (2) adding some more roll sulphur. Heat slowly until melted. Continue heating and test the viscosity of the sulphur by tilting the test tube. Note the successive changes in viscosity and color as the sulphur is brought to the boiling point. Look down the test tube **(arm's length)** at the boiling sulphur. Vapor? Pour the boiling sulphur into water (Text, page 199) and examine the plastic sulphur.

(7) Divide the plastic sulphur into two parts. To one add carbon disulphide and shake. Filter. Place some of the filtrate on a watch glass and allow to evaporate. Result? Is plastic sulphur soluble? Leave the other part for a day or two. Examine it. Result?

(8) Place a little roll sulphur in a deflagrating spoon and ignite by holding in a Bunsen flame. Note the size and color of the flame. Smell cautiously. Scoop with hand. Equation? Lower the burning sulphur into a bottle of air containing 10 ml. of a dilute potassium permanganate solution. Shake and observe. (Text, 204, 224.)

(9) Using the same test tube boil some more sulphur and lower a strip of copper foil into the sulphur vapor. Results? Equation? Is it cheaper to throw the tube out or clean it?

B. Hydrogen Sulphide

CARE. This gas is poisonous and one part in two hundred of air is fatal. Bleaching powder sprinkled with acetic acid gives enough chlorine to serve as an antidote. Equation?

1. Set up the apparatus as on page 201 of text. A Kipp generator could be used. Add dilute hydrochloric acid through the thistle tube until the ferrous sulphide sticks are well covered. Collect six bottles by the upward displacement of air. Equation? Bring to the mouth of the bottle a small piece of filter paper soaked in a lead acetate solution. How do you know when the bottle is full? Equation? Why collect by the upward displacement? Make a solution of the gas in water as shown in the text.

(2) Use one bottle to test the color, odor, and solubility of the gas.

(3) In the second bottle use moist red and blue litmus paper. Result? Place a ten cent piece in the bottle until the end of the period. Result? Equation? Ever clean silverware at home? What was the tarnish? Where did the hydrogen sulphide come from, and is it responsible for all the tarnish?

(4) Into the third bottle lower a blazing splint. Observe carefully and account for the results. Equations? What is on the inside of the bottle? Where from?

(5) Into the fourth bottle pour some lead acetate solution. Result? Equation? Would any other soluble lead salt do? Why? Verify by experiment.

(6) Lower some burning sulphur on a deflagrating spoon into a jar of air. Withdraw the spoon when flame is extinguished. Place this bottle of sulphur dioxide (equation?) over a bottle of hydrogen sulphide and let stand for a few minutes. Equation? Add a few drops of water if no reaction. Test the solution of hydrogen sulphide formed after you collected the six bottles (see text again.) Is it acidic? Equation?

(7) Hydrogen sulphide gas or its water solution is used to detect the presence of metal ions in a solution. Use 20 ml. samples of each of the following solutions: copper nitrate, lead nitrate, zinc sulphate, arsenic trichloride, antimony trichloride. The last two are very poisonous! Add in turn to each test tube about 2 ml. of the freshly prepared hydrogen sulphide solution. Results? Equations? Write equations for the complete and incomplete combustion of hydrogen sulphide. Why did we collect **six** bottles of the gas?

C. Sulphur Dioxide

(1) Set up the apparatus as shown on page 203 of text. Use a concentrated solution of sodium bisulphite. Control the rate at which sulphuric acid drops into the flask so that a steady flow of sulphur dioxide is produced. Collect four bottles of the gas by the upward (Why?) displacement of air (Why?). Leave sitting upright (Why?) and covered (Why?) with a sheet of glass. Place a funnel on the end of the delivery tube as illustrated and make a solution of the gas. (Why the funnel?) Equations for the preparation and solution.

(2) With the first jar note the color, odor (**Care**), and solubility of the gas. Shake an inch of water in the jar. Does it "pull" the hand which is held over the mouth of the jar? If so, why? Equation? Test with litmus. Result?

(3) Use the next jar and note the effect of the gas on moist litmus. Now lower a blazing splint into the bottle. Does the gas burn? Support combustion? How could you put out a chimney fire?

(4) To the third bottle add a dilute solution of potassium permanganate. Result? Why? Test for SO_2 gas? Add 2 ml. of barium chloride solution and note the result. Finally, add 2 ml. of dilute hydrochloric acid. Result? Write equations for the two reactions. (Text, 208.)

(5) In the last bottle place a thoroughly moistened flower and observe for a few minutes. What happened and why? Now hold the flower in the fumes from concentrated nitric acid. Result? Why? What color is an old straw hat? Why? Substances bleached with sulphur dioxide often return to the original color. What color are the keys an a new and on a very old piano? Explain bleaching with the aid of an equation.

(6) Use some of the sulphurous acid made by pouring a little of it on a piece of magnesium ribbon in a test tube. How would you identify the gas given off? Equations? To another 10 ml. portion of the sulphurous acid add a little barium chloride and shake the test tube. Add dilute hydrochloric acid a few drops at a time until no further change takes place. Write equations. Allow some of the sulphurous acid to be exposed to the air until next period. Now repeat the barium chloride and hydrochloric acid routine. Results this time? Equations? Could you tell a sulphite from a sulphate? (Text, 208.)

D. Sulphuric Acid (Demonstration)

1. Use a three-holed rubber stopper. In one hole insert a short piece of glass tubing to act as an outlet. In the next hole insert the delivery tube from a sulphur dioxide generator. (Part C) In the last hole insert the delivery tube from a Pyrex test tube containing some lead nitrate. Heat the nitrate until the gas jar is full of brown fumes. Equation? Now allow the sulphuric acid to drop slowly into the bisulphite solution evolving sulphur dioxide. Always have brown fumes in the gas bottle. Why? Describe the appearance of the inside of the gas jar. When the brown fumes are no longer evolved, disconnect. Add a few drops of water to the bottle. Result? Equation? Divide the solution just produced into 2 parts. To one add barium chloride followed by 2 ml. dilute hydrochloric acid. Add a small piece of mossy zinc to the other and test the gas. Equations?

2. Add, with constant stirring, 100 ml. of concentrated sulphuric acid to 50 ml. of water. Record the temperature before and after. Explain why water must **NEVER** be added to concentrated sulphuric acid. (Text, 46, 206.)

3. Use a small beaker, placing in it some sucrose, or cane sugar, ($C_{12}H_{22}O_{11}$) and add enough concentrated sulphuric acid to just cover the sugar. Result? Equation? What role does sulphuric acid play in the reaction?

4. Dip a wooden splint into concentrated acid and observe the result. Why? Wood contains cellulose which is a carbohydrate $(C_6H_{10}O_5)_n$. Equation?

5. Dip a glass tube into the concentrated acid and write on a filter paper. Describe and account for the result.

9

CRYSTAL STRUCTURE; ELECTROLYSIS; HYDROGEN CHLORIDE GAS; SOLVAY PROCESS

Demonstration 6

Laboratory Exercise 9

Reference: Text, Chapter 20, pages 211-219 (see note in Preface)

A. Crystal Structure

Use two test tubes of the same size and half fill one with cold water and half fill the other with boiling water. To each add a level teaspoonful of common salt. Study the solubility curves on page 77 of the text and predict the outcome of the experiment. Shake the tubes vigorously and allow them to stand until the undissolved salt has settled. What would be your description of the solutions (Text, page 74)? Is there a noticeable difference in the amount of salt remaining? Filter each separately and divide the filtrate into two parts. You now have four parts. Evaporate rapidly to dryness by means of a Bunsen one part of the cold solution and one part of the hot solution. Allow the other two parts to slowly evaporate to dryness. Now compare the four. Is there a difference in the residue from rapid evaporation and slow evaporation? Select one large crystal and examine with a magnifying glass. (Text, 213).

B. Electrolysis (Demonstration)

Set up a Hoffman's apparatus (Text, page 65) with a strong sodium chloride solution. Use a direct current of electricity. Why? Study carefully the **two** explanations as given on pages 214 and 215 of text. If using three or four dry cells start the experiment well before class time. If using a D.C. from a rectifier on 110 volts, use a lamp or some other resistance in series in the circuit. Observe the action at each electrode. Is the volume of gas in each arm the same? Should they be? Why are they different? Colors? Which gas gathers at the anode? At the cathode? Bring a lighted splint to a test tube filled with the gas from the cathode arm. Note the odor of the other gas (**Care!**) Test with a piece of moist blue litmus paper. Test the liquid in the electrolysis apparatus with red litmus. Test a salt solution with red litmus. Why the difference? Equations for the main reaction?

C. Hydrogen Chloride Gas

Set up apparatus as on page 216 of text using four teaspoons of common salt and add enough water to just moisten. Add concentrated sulphuric acid making sure the end of the thistle tube is in the solution. Why? Heat gently and add more acid as needed. Collect two jars of the gas as well as two test tubes full by upward displacement of air. What properties of the gas are shown by this method of collection? Note the color and odor (**Care**) of the gas. Blow very gently across the mouth of the tube. Why the "cloud effect"? Invert the other tube in water. What about the solubility of HCl gas? Insert a blazing splint into one of the bottles. Does it burn? Does it support combustion? Moisten a sheet of filter paper with ammonium hydroxide and drop into the second bottle. Explain and account for the results. Equation? Hold an ammonium hydroxide bottle and a hydrochloric acid bottle mouth to mouth and gently blow. (Smoke for Drama class?) Use some of the solution formed after collecting the gas. Test with various indicators (Recall Exercise 2). Half fill four test tubes with the solution and test with each of the following: zinc, magnesium, washing soda crystals, and silver nitrate solution. What is the gas evolved in the first two? Equations? Test the gas with a blazing splint. **(Demonstration.)** Set up a hydrogen chloride fountain as shown in paye 217 of text. Explain the formation and color of the fountain.

D. Solvay Process (Demonstration)

Saturate 200 cc. 6N NH_4OH with NaCl. Pass in CO_2 to the ammoniated brine solution. Shake the flask vigorously, frequently cooling under the tap. In about 5 minutes a heavy white precipitate of $NaHCO_3$ will form. Show at least five equations. How is Na_2CO_3 prepared? What is sal soda? How can you prepare washing soda? Equation? How is pure sodium bicarbonate formed? Why this way?

12

IODINE; HYDROGEN IODIDE; FLUORINE

Demonstration 9

Laboratory Exercise 10

Reference: Text, Chapter 21, pages 220-233

Caution. Care should be taken not to inhale the fumes.

Set up the apparatus as shown on page 229 of text. Thoroughly mix 3 gm. of powdered sodium iodide and 2 gm. of manganese dioxide. Place this mixture in a beaker. Fill the evaporating dish with COLD water. Add about 10 ml. of concentrated sulphuric acid to the beaker and stir thoroughly. Apply a very gentle heat, moving the burner about. Equation? Note the colored vapor formed which slowly condenses on the bottom of the evaporating dish. Color of the crystals? Sublimation? Is it a two way process? Give everyday examples of sublimation.

Warm a crystal of iodine in a test tube. What do you observe concerning the crystal and the walls of the test tube beyond the area heated? Sublimation. Meaning?

Place a few crystals of iodine in a mortar. Add a small drop of mercury. Grind the two together with a pestle. Equation? (**Care:** the product is a poison.)

In a beaker vaporize a few crystals of iodine. Sprinkle some powdered antimony into the beaker. Result? Equation?

Place a few crystals of iodine in each of eight dry test tubes. Fill out the table shown below:

Solute	Solvent	Soluble Slightly Soluble or Insoluble	Color of Solution	Which would make a good test? Check. √
Iodine	Water			
Iodine	Water solution of KI			
Iodine	Carbon disulphide			
Iodine	Carbon tetrachloride			
Iodine	Methyl Alcohol			
Iodine	Ethyl alcohol			
Iodine	Ether			
Iodine	Chloroform			

To each solution above add a few drops of starch solution. Result? (The starch test for iodine is an extremely sensitive one. It works best with a very dilute solution.)

To make a starch solution put a teaspoon of corn starch into a 250 ml. flask and half fill with water. Heat until the mixture appears translucent. Add water to make the mixture pour easily. In testing with this solution it may be necessary to dilute with water until a recognizable color is produced.

In each of two test tubes put about 5 ml. of potassium iodide solution. To one add a few cc. of chlorine water; to the other a few cc. of bromine water. Results? Equations? To each add a few drops of starch solution. Results?

Dissolve a little potassium iodide in one-third test tube of water. Add a few ml. of carbon disulphide (or tetrachloride) and shake. Result? Why? To this add a little chlorine water. Shake. Allow to stand. Result? Why? Equation?

Hydrogen iodide is less stable than hydrogen bromide. What reaction would you expect to take place when concentrated sulphuric acid is added to a crystal of potassium iodide (207 and high B.P.; 216; 251).

Complete the equations:

$H_2SO_4 + KI \longrightarrow$

$H_2SO_4 + 8HI \longrightarrow$

Hydrogen iodide is less stable than hydrogen bromide. Distinguish between the terms hydrogen iodide and hydriodic acid.

Demonstration: Text, page 221. Make a thick paste of calcium fluoride and sulphuric acid in a lead (Why?) dish. Warm gently. Equation? Cover the dish with a piece of glass which has been coated with a thin layer of wax. With the point of a knife scratch a design in the wax. The HF fumes that are produced react with the glass (SiO_2) and etch it. Equations?

Fill in the chart on page 34 re I_2.

Complete with help of texts the F_2.

Memorize Page 34.

13

CHLORIDES; BROMIDES; IODIDES

Laboratory Exercise 11

Reference: Text, Chapter 21, pages 220-233

Make up a strong solution of each of the following: sodium chloride, sodium bromide, and sodium iodide. Make them the same strength. **Calculate.**

A. Place three test tubes in a rack. Put about one-half inch of chloride solution in the first; one-half inch of bromide solution in the second; and one-half inch of iodide solution in the third. To each add 5 drops of silver nitrate solution. Equations? Note the color and nature of each precipitate. Record results in table below.

Divide the contents of **each** test tube in turn into **three parts.** To the first part add one-third test tube full of ammonium hydroxide; to the second part add one-third tube of dilute nitric acid; set the last tube in the light. Repeat these operations with the bromide and the iodide. Fill in the table.

Salt	Agent	Nature of the ppt.	Color of the ppt.	Equation for the reaction	HNO_3	NH_4OH	Light
NaCl							
NaBr							
NaI							

B. Arrange three tubes as before using another portion of the chloride, bromide, and iodide solutions. To each add 5 ml. carbon disulphide (or tetrachloride). Shake. Allow to stand. Color of bottom layer? Now add to each 5 ml. of chlorine water. Shake. Allow to stand. Color of the bottom layer? What is the function of chlorine water? Equations? Fill in the table.

Salt	CCl_4 and shake	Color	Cl_2 water and shake	Result	Equation
NaCl					
NaBr					
NaI					

C. Arrange three test tubes as before. Thoroughly mix in a mortar a small amount of crystaline sodium chloride the size of a pea with an equal amount of manganese dioxide. Transfer to first tube. In the second put a mixture of sodium bromide and MnO_2. In the third NaI and MnO_2. Set the tubes in the hood. Add enough concentrated sulphuric acid to soak the mixtures and then warm **gently.** In the first case hold a piece of damp blue litmus paper in the tube. Result? How can you distinguish between chlorides, bromides, and iodides? Fill in the table.

Salt	Agents used	Observations	Equations
NaCl			
NaBr			
NaI			

The silver nitrate test will enable you to tell whether or not a given compound belongs to the group composed of chlorides, bromides, iodides. Either the test with manganese dioxide and sulphuric acid **or** with chlorine water and carbon tetrachloride will enable you to distinguish the three members of the group one from another. Which method do YOU prefer? Why?

Work through the unknown salts given you and try to identify each. They do not have to be halogens, so be careful.

When the three tables are completed and checked for correct responses then **MEMORIZE** them.

14

AMMONIA; NITRIC ACID; NITRATES; OXIDES OF NITROGEN

Demonstration 10

Laboratory Exercise 12

Reference: Text, Chapter 24, pages 247-258

A. Ammonia

Set up the apparatus as on page 248 of text. Use one teaspoonful of ammonium chloride and an equal amount of calcium hydroxide. Blend well by shaking the tube. Clamp in position and heat gently and collect three bottles by the downward displacement of air. What facts about the gas are shown by this method of collection? Hold moist red litmus at the mouth of the bottle. Why does this tell when the bottle is full? Equation? When bottles are filled with ammonia (equation for preparation) place them mouth downward. Why? Run balance of ammonia into beaker as shown.

1. Use one of the bottles to test with blazing splint shoved upward into a bottle held with its mouth downward. What two properties are illustrated? What is the difference between ammonia and ammonium? Color and odor of ammonia?

2. Set the second bottle mouth upward and set on it mouth downward another gas bottle in which five drops of concentrated hydrochloric acid had been well shaken. Describe and account for the action within the bottles. Equation?

3. Set the third bottle in a large beaker half full of water. Describe and account for the change.

4. Set up the ammonia fountain shown on page 249 of text. Describe and account for the result. (Part 4 is a demonstration.)

B. Nitric Acid

Set up apparatus as on page 251 of text. When no more acid collects in the flask remove the flame and examine both retort and flask. Describe the product in each. Equation? Has nitric acid a low boiling point? How do you know from the experiment? For the following experiments it is more convenient to use the concentrated acid from your reagent bottle.

1. Place some egg white in an evaporating dish and add 2 ml. concentrated nitric acid. Heat and observe the changes. Did you ever accidentally spill any of the concentrated acid on your fingers? Xanthoproteic reaction is a protein test. Meaning?

2. Add a drop of the concentrated acid to one-third test tube of water. Taste a drop of this solution. Test with litmus.

3. Drop a small piece of zinc into 5 ml. of dilute acid in a test tube. Equation? Test the escaping gas with a blazing splint. Result?

4. Place a small piece of copper in a test tube and add dilute nitric acid. Repeat with concentrated acid. What is observed in each case? Name the products and write the equations.

5. Boil (Caution: when nitric acid boils, the liquid may splatter from the tube.) a small piece of sulphur in nitric acid (**demonstration**)and test the solution with barium chloride solution for a sulphate. What important property of nitric acid is shown? Equations for the reactions? Why is sulphuric acid used for the preparation of nitric acid? Why is nitric acid a strong acid? Why is not hydrogen produced when metals are added to the acid?

C. Nitrates

Carry out the nitrate test as shown on pages 254 and 316 of text. Test various nitrates. Be sure the ferrous sulphate is **freshly prepared**—do it yourself. Why is sulphuric acid added to the mixture in testing for a nitrate? This is a delicate test. How weak a solution can you make respond?

D. Oxides

Set up apparatus as on page 255 of text for nitrous oxide. Use 15 gm. of ammonium nitrate. **Heat gently. (Caution:** Ammonia nitrate may explode if heated too rapidly.) Collect two bottles. Observe the color and odor and solubility. Insert a glowing splint into second jar. Write equations for all reactions. **Nitric oxide** (Text, page 256). Use 20 gm. copper turnings. Add sufficient dilute nitric acid to cover copper. Warm gently. Collect three bottles. Equation? Leave the last bottle in the trough. Color of the gas? Remove the glass plate and account for the color change. Equation? Lower a burning splint into second jar. Does the gas burn? Does it support combustion? Slowly add oxygen from a generator to third bottle. What happens? Equation? A test for oxygen?

CALCIUM AND MAGNESIUM COMPOUNDS

Laboratory Exercise 13

Reference: Text, Chapter 25, pages 259-269

1. **Limestone caves:**

Stalactites and stalagmites (Text, page 265). Other pictures? Put 50 ml. of clear limewater in a beaker and blow your breath through it by means of a glass tube or connect with a CO_2 generator. Result? Equation? Continue this operation until the suspension clears. Equation? How is this connected with limestone cave formation?

2. **Making lime:**

Place a piece of marble in a clean crucible and heat strongly for 20 minutes. Cool and examine. Equation? Test with moist red litmus. Place the powder in a test tube and add a little water. Temperature change? Equation? Test with red and blue litmus. Result? Which is the slaked lime and which is the quicklime? (Text, page 261). What is air-slaked lime?

3. **Mortar:**

Mix together small quantities of quicklime, CaO, and sand, SiO_2, in the proportion of 2:1 by volume. Add just enough water to make a thick paste. Pour into a broken test tube or a small match box and set aside. Examine next week for appearance and hardness. Equations? (261.)

4. **Bleaching powder:** (Bottle C, page 222 of text)

To a little $CaOCl_2$ add some dilute acid. Use a beaker. Smell cautiously. Equations for the preparation and use of bleaching powder. Does the chlorine do the bleaching? Equation.

5. **Plaster of Paris:**

Place in an evaporating dish a tablespoonful of plaster of Paris and add enough water to make a thick paste. Lightly coat an old saucer with vaseline and put the paste in the saucer. Wash the evaporating dish. Wet a coin with kerosene and press into the paste. Set aside for 15 minutes to harden. Remove the coin and examine the impression. (262.)

6. **Hard waters:**

To soften hard water the free calcium ions must be removed. Ca, Mg, Fe, Ba ions as bicarbonates form temporary hardness. The chlorides and sulphates form permanently hard waters. What is the difference?

(a) To a test tube half full of distilled water add one drop of soap solution. Cover the mouth of the test tube with your thumb and shake ten times. Continue to add soap solution **a drop at a time,** shaking after each drop, until a permanent lather (one that lasts a minute) forms. How many drops are required? Why is distilled water "soft"?

(b) Use a half test tube of limewater and bubble CO_2 through it until the precipitate dissolves. The water now containing calcium bicarbonate is said to be temporary hard water. Add soap as above. How many drops required **to form permanent lather?**

Soap is $Na(C_{18}H_{35}O_2)$. Write the required equations for parts (b) and (f). What are the "curds"?

(c) Use a half test tube of temporary hard water. Gently boil. Pass any gas evolved through lime water in a second tube. Add soap as above. Results? Why? Compare with the amount of soap used in (a) above. Equation re boiling?

(d) Use a half test tube of temporary hard water. Add a crystal of washing soda. How many drops of soap solution are needed to produce a permanent lather? What does the soda do? Equation?

(e) To another tube of temporary hard water add limewater drop by drop until no precipitate forms. Equation? Filter. Add soap as before. Compare with (a).

(f) Permanent hard water: Use calcium sulphate solution. Add soap as in (a). Equation?

(g) As in (f) but boil for three minutes. Add soap, etc. Result?

(h) Sulphate solution and washing soda. Equation? Now add soap. Compare. Why is washing soda an effective water softener?

METALLURGY: ALLOYS

Demonstration 11

Laboratory Exercise 14

Reference: Text, Chapter 27, pages 282-291

1. Reduction with Carbon:

Carve out a small cavity, by rotating a dime, in a charcoal block. In this hole place a small amount of litharge (PbO). Heat with a reducing flame using a blowpipe until globules of the metal form. Equation? Other examples of reduction could be passing of hydrogen over heated copper oxide (Equation? See Text, page 51) or the use of aluminum in thermit welding (Text, page 299). A commercial reduction method? Others?

A reducing flame: A flame of this nature is obtained by using a small yellow bunsen flame. The blowpipe is placed just outside the flame and the yellow cone of flame is played on the litharge.

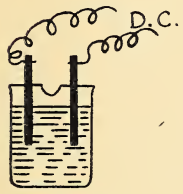
2. Roasting in Air

Roasting is generally used for sulphide ores to remove the sulphur. The roasting produces the oxide which then is reduced. Commercially what is done with the SO_2? Place some lead sulphide or copper sulphide in a crucible and heat strongly for a few minutes. Smell the gas evolved. Equation? The crucible now contains PbO or CuO and reddish brown Cu_2O.

Reduction is carried on as in part 1. Equations?

If cinnabar (HgS) is roasted the mercury is set free. Equation? Others?

3. Electrolysis (Demonstration)



Arrange the apparatus as shown using a copper sulphate solution. The electrodes are carbon rods. A direct current of electricity is required. Why? Leave the current on for ten minutes. Examine both electrodes. Results? Write IONIC equations. Why the oxygen at the anode?

Write equations for the reactions of the Downs cell on page 241 of text, and the Castner process on page 242 of text. Show **ions**. The Hall process for the extraction of Al (Text, pages 295-6.) OTHERS?

In electrolysis the ore is in solution (explain) or it is in the fused state (explain), and the metal is deposited and collected at the electrode (Name?).

Are all metals extracted by electrolysis? Reason for your answer. Why cannot certain metals be extracted by reduction? Name two. What is the "free" state in which metals are found? Name three. How are they "extracted"? What is the difference between a mineral and an ore?

4. Extractives

Describe this process and give examples.

5 Alloys (Demonstration)

References: 308, 299, 314, 326

A. A low-melting-point alloy. Cover a piece of heavy paper (2"x4") with a thin layer of vaseline, and shape it into the form of a tube by rolling it, greased side inward, around a piece of glass tubing. Remove the tubing and close one end of the paper tube by folding.

Weigh out the metals in the amounts indicated: 2 gm. of bismuth; 1 gm. lead; 0.5 gm. of tin; 0.5 gm. of cadmium. Put the metals into a clean crucible and heat gently. Gradually increase the heat until the metals melt. Stir well with a file to insure thorough mixing of the metals. What is an alloy?

Hold the closed end of the paper tube with forceps and pour into it the melted mixture of metals. Allow to cool and then remove the paper from the metal rod. You have prepared an alloy known as Wood's Metal. Examine it as to color, density, hardness and strength, and compare with the properties of the metals composing the alloy.

Half fill a beaker with water. Suspend a thermometer in the water. Slowly heat the water while stirring it constantly with the rod of Wood's Metal. Observe the rod closely and note temperature at which it melts. Allow all the alloy to melt and then remove the heat. Note the temperature at which the alloy freezes (solidifies). Uses of Wood's Metal?

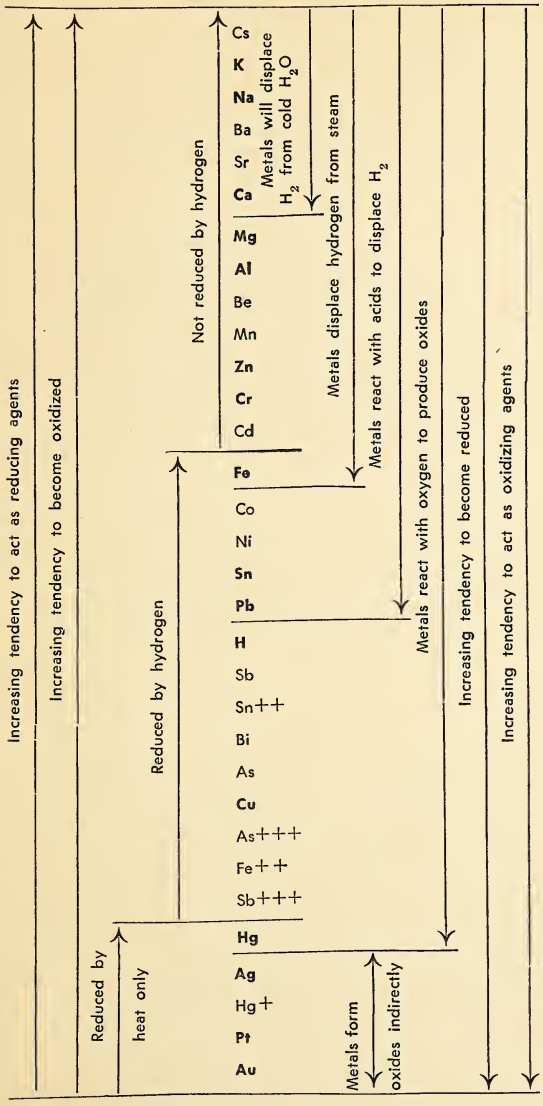
B. Place a few small pieces of brass (326) in a beaker and slowly add some nitric acid. Dilute with water when action ceases. Why the color? Equation.

THE ACTIVITY SERIES

Denmonstration 12

Laboratory Exercise 15

References: Text, page 45; Chapter 27, pages 282-291



The elements arranged in their order of decreasing electrode potentials are known as the Activity Series.

This series, then, has the most active electron-losers at the top and the most active electron-acceptors at the bottom. The greater the tendency to lose electrons, the higher on the series.

Oxidation is considered as a **loss** of electrons with a gain in valence (loss of electrons is oxidation L-E-O) while reduction, being a reverse process, is considered as a **gain** of electrons with a **loss** in valence (gain of electrons is reduction G-E-R). With all due respect to M-G-M and their lion Leo just remember that **LEO the lion says GER.** 285.

At the head of the Activity Series are the elements which are most easily oxidized and hence the best reducing agents. As one proceeds down the table, the elements show a greater tendency to move into the reduced state or less tendency to move into the oxidized state. Therefore the most easily reduced substances and the best oxidizing agents are at the foot of the table.

A "more useful" way of looking at the Activity Series is based upon the ability of one metal to replace another from a solution of a salt of the the latter.

Note: Those in black face type are in the text and are the ones you must memorize.

1. Demonstration—Sodium stands high in the series and hence is capable of entering into many displacement reactions. (a) Heat some sodium metal with zinc chloride. After reaction flush with water **(CARE)** Why? Filter. With blowpipe and charcoal block get a bead of zinc. Equation. (b) Repeat using aluminum chloride getting an aluminum bead. Equation. (This was the method prior to the Hall Process). (c) Water on the whole is a covalent compound but it does on the whole break up into a very, very few hydrogen ions and hydroxyl ions. Equation. When sodium is dropped into water hydrogen gas escapes. IONIC equation. Drop some SMALL pieces of sodium in water in a beaker **(Care:** Stand well back or cover with a sheet of glass). Test with litmus. Equation. Repeat with potassium. Why the flame this time? Why the color?

2. "Christmas Tree" demonstration. From a piece of copper foil cut out a small Christmas tree. (Two interlocking will stand up). Place in a silver nitrate solution. Account for the results. IONIC equation showing electron transfer by means of arrows (285). Redox equation.

3. Magnesium ribbon, granular zinc, iron nails (not coated) and copper turnings. Solutions of magnesium sulphate, zinc sulphate, cupric sulphate and silver nitrate (Do not get the nitrate on the hands or clothing. Why?) Put about one inch of each solution into separate test tubes. Add a one inch strip of magnesium ribbon to each. Allow to stand for five minutes. Describe any changes on the magnesium or the colors of the solutions. Equations. (As a rule metals in a very finely divided form are black). Wash up.

Repeat the experiment using a granule, or a strip of zinc, then an iron nail, and finally some copper turnings in place of the magnesium ribbon. Use a new solution each time. Show IONIC equations for all reactions. Record your results.

	Magnesium	Zinc	Iron	Copper
Magnesium sulphate				
Zinc sulphate				
Cupric sulphate				
Silver nitrate				

ALUMINUM; Al TEST; PURE WATER; MORDANT

Demonstration 13

Laboratory Exercise 16

Reference: Text, Chapter 28, pages 292-302

1. Aluminum the metal

Put some aluminum turnings in a large test tube and add 25 ml. of 6N hydrochloric acid. Note that after the protective coating (meaning) is desroyed, a vigorous evolution of hydrogen ensues, Equation?

Repeat using 6N sodium hydroxide instead of the HCl. Hydrogen is again evolved. Equations? Aluminum is an amphoteric element. What is the meaning of this term? Other examples?

2. Aluminum Hydroxide

To 100 ml. of water in a beaker add 50 ml. of 0.5N $Al_2(SO_4)_3$ solution and 20 ml. 6N ammonium hydroxide and stir. Equation? Divide into two parts. In one dissolve the aluminum hydroxide by adding an excess of concentrated hydrochloric acid and stir. Equation? To the other part add an excess of 6N sodium hydroxide solution. Equation?

Remember that $Al(OH)_3$ acts like a base when treated with an acid, but acts like an acid when treated with a strong base. Amphoterism, page 300, text.

3. Blowpipe test

Make some more aluminum hydroxide as in part 2 above. Filter. Pour boiling water on the filter paper to wash the aluminum hydroxide. Take some of the aluminum hydroxide and place it in a hole scraped in a charcoal block. Heat strongly with a reducing flame (page 45, Lab Manual) until it appears dry and white. Add **two drops** of cobalt nitrate solution. Heat again. Color when cool? This provides a good test for the aluminum ion.

4. **Purification of Water**

Prepare some murky water by stirring a handful of soil in some water. Allow to settle. Pour off the cloudy water for this experiment. Put some in each of two beakers. To one add about 2 ml. of alum solution or a solution of aluminum sulphate and then several ml. of limewater. Why add the base? Allow to stand and observe at five minute intervals. (Text, pages 58 and 300). Result? Equation? Put some of the murky water in a long tube and cork. Leave standing for a month. Will it become crystal clear? Ever? Why?

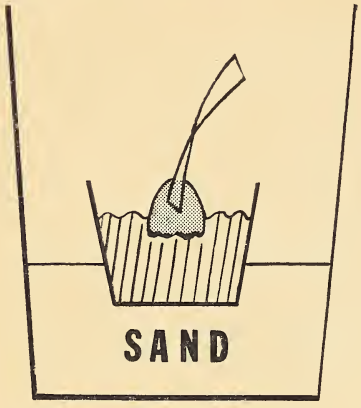
5. Aluminum hydroxide as a mordant

Place a small piece of white cloth (a gun square for cleaning 22's) in a dish one-third full of logwood solution (or other dye). Boil for one minute. Remove the cloth and wash it thoroughly with water and dry. Result?

Now mordant a square by first soaking it in an aluminum sulphate solution. Squeeze out the excess liquid and then place it in an ammonium hydroxide solution. Again squeeze out the excess liquid. What is formed IN the fibres of the cloth? Equation? Place the mordanted cloth in the logwood solution and boil a minute. Wash with water as before and dry. Compare the two pieces of dyed material. Conclusion?

6. Thermit Process (Demonstration)

(CARE Follow the precautions carefully or do not do the experiment.)



A mixture of 1 gm. powdered aluminum and 3 gm. iron oxide Fe_2O_3 or Fe_3O_4) is known as Thermit. (Incendiary bombs?) Use a LARGE pail with at least six inches of sand in the bottom. Place 3-4 teasponfuls of thermit in a crucible. Add the ignition mixture of powdered magnesium and barium peroxide. In this place a six inch strip of magnesium ribbon. Light the ribbon and **stand back**. All reactions are exothermic. (Meaning.) Write the three equations. For the main reaction show valence change to show it as an oxidation-reduction reaction. What substance is reduced? Name the reducing agent. Name the oxidizing agent.

STEEL; -OUS AND -IC

Demonstration 14

Laboratory Exercise 17

Reference: Text, Chapter 29, pages 303-319

A. Tempering (313)

The hardness of steel depends upon its composition and history—the way the metal has been cooled—and on its subsequent heat treatment.

A typical steel, containing nearly one percent of carbon, when heated to a high temperature and suddenly chilled (quenched) becomes so hard it will scratch glass, and so brittle it will not bend very far without breaking. The operation is called **hardening steel** (1350° and over). If the hardened steel be reheated to its original high temperature and then slowly cooled—"letting down" or **annealing**—it will become soft and ductile (1020°-1200° F). By reheating hardened steel to certain very definite temperatures, depending on what the steel will be used for (from 200° and upward) then cooling under definite conditions, steels can be obtained of varying, yet definite, degrees of hardness. The process of reheating a hardened steel to a temperature far short of that employed when the steel was hardened is called **tempering steel.**

1. Take a piece of clock spring and heat it strongly in the Bunsen burner. Allow it to cool **slowly** (begin by holding it in the hot air above and then at the side of the flame). Set aside to finish cooling. Now try to bend it. Does it bend easily, or is it springy?
2. Once more heat it strongly, and cool it **suddenly** by plunging it into a beaker of water right at hand. Again try to bend it. Result?
3. Heat it a third time and cool it slowly as at first. Does it bend easily now?

B. Ferrous and Ferric ions (316-317)

Use freshly prepared ferrous and ferric salts. Fill half-full each of five test tubes with the ferrous solution and half fill another five with the ferric solution. Note the color of the two solutions; the reaction when ammonium hydroxide is added to each; add a little potassium ferrocyanide to each salt and compare the result with the addition of potassum ferricyanide to another pair of test tubes. To the last pair add some potassium thiocyanate. Where possible, write equations. Fill in the chart below showing the color of the precipitate or solution. Memorize the table after having it checked for correct responses.

Reagent	Ferrous Fe^{++}	Ferric Fe^{+++}
1. Color of the solution		
2. NH_4OH		
3. $K_4Fe(CN)_6$ (ferro-)		
4. $K_3Fe(CN)_6$ (ferri-)		
5. KCNS		

Could you identify BOTH the ferrous and the ferric ions if present in the same solution? How?

C. Ferrous and Ferric Salts

Put as much finely powdered iron as will sit on a dime, in a test tube and add about one half inch of dilute hydrochloric acid. Equation. Filter. Use one quarter of the filtrate and test as in Part B above for -ous iron. Use another quarter and add 6-8 drops hydrochloric acid and a small piece of iron wire (or 1 or 2 tacks) and **loosely** cork the tube. This prevents the oxidation of the ferrous chloride to ferric chloride by the oxygen of the air. Try the brown ring test (316). Use another quarter of the filtrate and shake it frequently as it stands in the room exposed to air. Color changes? Equation? Test as in Part B above. What has happened to the positive valence of the iron? Oxidation or reduction?

D. Oxidation of a Ferrous Compound

Use the remaining quarter of the filtrate by adding some chlorine water and shake the tube. Test for -ic salt. IONIC equation. (285). Determine the valence change of the iron. Has the positive valence increased or decreased? Oxidation or reduction? What has happened to the valence of the chlorine? Is it oxidized or reduced?

E. Reduction of a Ferric Compound

Add some finely divided iron and 3 ml. of dilute hydrochloric acid to 15 ml. of ferric chloride solution in a test tube. Colors? Equation (286)? After reaction has stopped, filter. Test as in Part B above. A redox reation? Discuss the valence change in the iron and hydrogen. Name the oxidizing agent and the reducing agent.

F. Blueprints (317) Demonstration

Soak some mimeograph paper in a solution of ferric ammonium citrate or sulphate. Let it dry in the dark. Place over this blueprint paper an article such as a key. leaf, photo-negative and put in the sunlight or under a photo-flood for several minutes. Remove the paper to a darkened room; immerse it in a solution of potassium ferricyanide for a minute. Wash in a tray of clean water. A blue print immage should be found on the paper. Equations.

COPPER AND SOME OF ITS COMPOUNDS; TESTS FOR COPPER

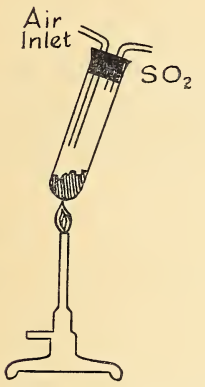
Demonstration 15

Laboratory Exercise 18

Reference: Text, Chapter 30, pages 320-329

1. **Metallurgy:** Parts 1-5 are demonstration.

On a spatula place a little CuS. Heat strongly and smell cautiously the gas given off. What is the gas? Equation? An alternate experiment is to place 20-30 gm. of the CuS in a large Pyrex test tube set up as shown. Force air in with an aspirator bulb. Here we roast a sulphide ore to get the oxide. Equation? Recall the reduction with H_2 as shown on page 51 of text. Equations? Carbon is also a reducing agent as shown on page 168 of text. Note that this reduction is an important step in the metallurgy of Cu.



2. **Compounds:**

Copper unites with nearly all the non-metals at high temperatures forming copper salts. Recall the experiment with chlorine. Equation? Add a strip of copper foil to a few drops of bromine in a test tube. Cork and set aside. Later carefully remove the copper. Add water. Color and why? Equation?

3. **Acids:**

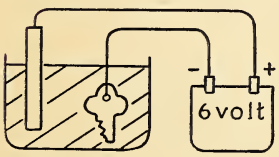
Nitric acid in sunlight or when heated is unstable (Text, page 252). Place a small strip of copper in an evaporating dish and add dilute nitric acid, a few drops at a time, until the copper is just dissolved. Equation? Repeat using concentrated acid. Equation? (Text, page 252). Add a piece of copper to 5 ml. of hot concentrated sulphuric acid (Text, page 207) in a test tube. **(CAUTION: handle the hot concentrated acid with care).** Does the color of the solution show evidence of action? Note that the OXIDIZING ACIDS YIELD REDUCTION PRODUCTS OF THE ACID. Meaning? (Text, page 326.) Set the sulphate solution aside to cool. Examine for crystals. ((328.)

4. **Bordeaux mixture:**

A very effective fungicide may be made by dissolving 2.25 gm. of $CuSO_4.5H_2O$ in 100 ml. of water. This makes a .09M solution (check). In a second beaker place 2.25 gm. CaO and add about 10 ml. water and wait until the slaking ceases and then add water to total 100 ml. Equation? Mix the suspension of $Ca(OH)_2$ with the $CuSO_4$ solution. The resulting mixture is the standard 4-4-50 Bordeaux mixutre. (328.)

5. **Electroplating:**

Half fill a 250 ml. beaker with copper sulphate solution. Place a copper strip in the solution and connect it with a wire to the positive terminal of a battery or to a small rectifier. Thoroughly clean the key or other metal object to be plated and connect to the negative terminal. Allow the current to flow for ten minutes. Remove the object and wipe off any liquid and loosely adhering metal. If the "plate" is too loose or spongy, repeat using less current. How? IONIC equations showing what is happening at each terminal? If it is possible connect an ammeter and a variable resistance in series with the cell. Adjust the current (How?) until it reads 0.3 to 0.5 amps. There will be a bright deposit on the cathode. Did the electrolyte appear to undergo any chemical change? Discuss. Why a D.C.? (A name plate **may** be made by using for the negative terminal a block of paraffin in which a name has been scratched. Coat the whole block with finely powdered graphite, attach to a copper wire and immerse it in the copper sulphate bath as the object to be plated. This illustrates in a crude way the process of electroplating.



6. **Anhydrous salt:**

In a test tube place a little finely crushed bluestone. Hold the mouth of the tube a little below the horizontal and heat the powder gently. Result? Equation? Why the position of the tube? What gathers on the cold part? Read pages 62 and 63 of text for the test for water. Equation?

7. **Cupric Oxide:**

To a **cold** solution of cupric sulphate add one-half its volume of sodium hydroxide solution. Cupric hydroxide, $Cu(OH)_2$, is precipitated. Equation? Now heat to boiling. The hydroxide is decomposed into water and black cupric oxide. Equation?

8. **Color of the cupric ion:**

In separate test tubes dissolve small amounts of copper sulphate, copper chloride, copper bromide, sodium chloride and potassium nitrate. Colors? Write ionic equations for the above solutions and state the color of each ion formed. Recall Exercise 1 (7).

9. **Copper sulphide:**

Try the reaction of ammonium sulphide on cupric sulphate. Result? Equation? Bubble hydrogen sulphide gas through some copper sulphate in a beaker. Result? Equation?

10. **Copper confirmation:**

There are other substances which react with H_2S gas in a similar manner to the previous part. Bubble H_2S through some copper sulphate. Filter. Place the precipitate in a beaker and add some dilute nitric acid and boil. Color now? Why? Equation? Add some 6N NH_4OH (easy does it. Why?) in excess (How do you **know** when it is in excess?) and note the color change. The deep blue color is due to the formation of $Cu(NH_3)_4{}^{++}$ ion.

11. **Tests for the presence of copper:**

(a) The solutions of copper (valence 2) salts are blue. Why?

(b) Pass H_2S into $CuSO_4$ solution and note the black CuS. Equation?

(c) Flame test: Moisten the end of a copper wire with hydrochloric acid and hold it in the edge of the Bunsen flame. Color?

(d) Put some copper sulphate in an evaporating dish and leave a bright iron nail in it for half a minute. Result? Equation? Why?

(e) Suspend a strip of copper in $AgNO_3$ solution. Observe and account for the results (Text, page 45). **Ionic** equation showing electron transfer for gain and loss of electrons? Oxidation: reduction.

(f) To about 3 ml. copper sulphate solution add a few drops of ammonium hydroxide and then a considerable quantity. Equations?

(g) To a dilute copper sulphate solution add about 1 ml. of potassium ferrocyanide. Stir. Result? Equation? Let the mixture stand for a few minutes.

21

ORGANIC COMPOUNDS

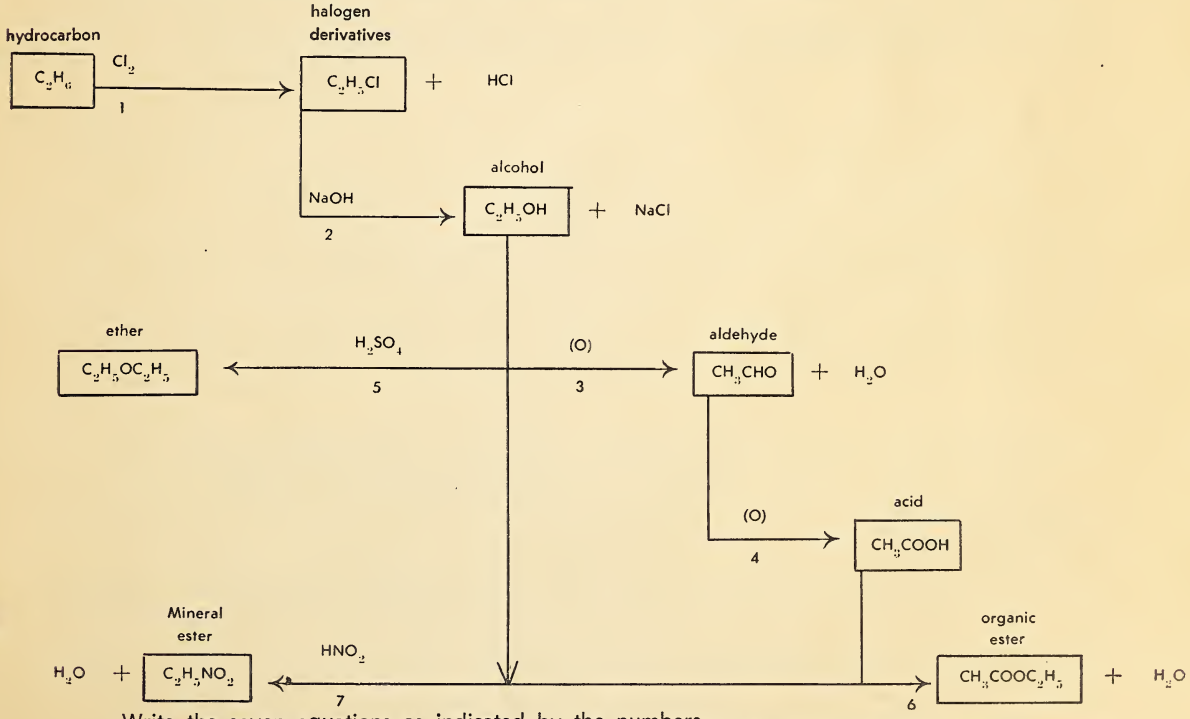
Demonstration 16

Laboratory Exercise 19

Reference: Text, Chapter 31, pages 330-346

A great variety of organic compounds can be derived by the substitution of covalently linked groups of atoms for hydrogen atoms in hydrocarbon molecules. Some of these compounds are actually prepared from the hydrocarbons; others are "derivatives" in a formal sense only.

Alcohols are regarded as products of the first stage of oxidation of the hydrocarbons. Aldehydes and ketones may be regarded as the products of the second stage of oxidation of a hydrocarbon. Ketones are characterized by the $>C=O$ group. Final oxidation gives the acid. Any alcohol and any acid give the ester. We may set up this "line of action" by this scheme: (336-337)
hydrocarbons ⟶ alcohols ⟶ aldehydes ⟶ acids ⟶ esters. Among the various derivatives the halogens form an important group. With the saturated hydrocarbons there are the substitution products and with the unsaturated hydrocarbons there are the addition products as well as the substitution products. Molecular formulas are inadequate for the needs of organic chemistry and structural formulas are used to map the molecules of organic compounds. Any organic compound is considered to be a hydrocarbon derivative if its structural formula shows that it may be looked upon as a hydrocarbon in which one or more atoms of hydrogen have been replaced by certain other atoms or radicals. When these ideas are applied, the study of organic chemistry does not seem so hopeless, for a large portion of the thousands of compounds may be thought of as hydrocarbon derivatives. Furthermore these compounds may be grouped in a few simple classes based upon the characteristic atom or radical attached to the residual part of the hydrocarbon molecule. The following flow chart will show the relations between certain of the classes of hydrocarbon derivatives, and will suggest possible, though not always profitable, methods of proceeding from one to another:



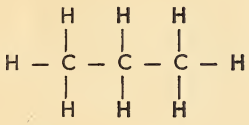
Write the seven equations as indicated by the numbers.

Identify the "family groups" for alcohol, aldehyde, acid, ether, and name each of the compounds as shown in the rectangles above.

Write the structure for each "family", e.g., $-C\overset{O}{\underset{H}{<}}$ for the aldehyde group. Learn the configuration of each "family". (337.)

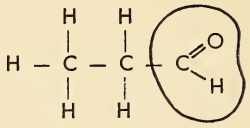
Class	Characteristic Group	Example	Formula of Example	
Methane series hydocarbons	C_nH_{2n+2}	Propane	$CH_3 . CH_2 . CH_3$	C_3H_8
Mono-chloro derivatives	R-Cl	Prophy chloride	$CH_3 . CH_2 . CH_2Cl$	C_3H_7Cl
Alcohol	R-OH	Propyl alcohol	$CH_3 . CH_2 . CH_2OH$	C_3H_7OH
Aldehyde	R-CHO	Propyl aldehyde	$CH_3 . CH_2 . CHO$	C_3H_6O
Organic acid	R-COOH	Propionic acid	$CH_3 . CH_2 . COOH$	$C_3H_6O_2$
Ketone	$\begin{matrix}R\\R\end{matrix}\!\!>\!CO$	Acetone	$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!CO$	$(CH_3)_2CO$
Ether	R-O-R	Di-ethyl ether	$CH_3 . CH_2 . O . CH_2 . CH_3$	$(C_2H_5)_2O$
Ester	R-COO-R	Ethyl acetate	$CH_3 . COO . CH_2 . CH_3$	$C_2H_5.C_2H_3O_2$

The above study surveys the field of hydrocarbons derivatives, and makes use of the idea of molecular structure to explain the classification of these compounds. With the aid of your text and other books draw the structural formula for the above compounds. Here is a little help.



$CH_3.CH_2.CH_3$

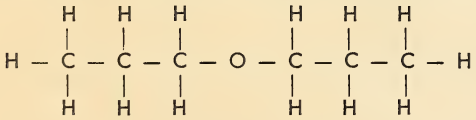
C_3H_8



What "family group" is shown here?

$CH_3.CH_2.CHO$

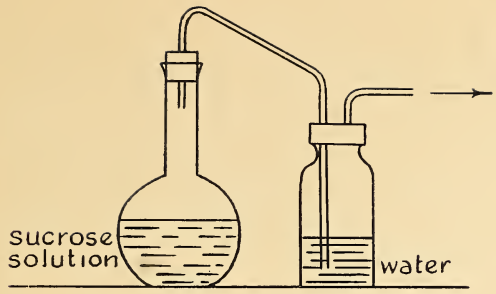
C_2H_5CHO



Name this one.
What is the "family group"?
Write its molecular formula showing its structure.
Write a simple molecular formula.

1. Alcohols (Demonstration)

Although alcohols may be prepared directly from the hydrocarbons, they are often prepared from other substances. Thus ethyl alcohol, C_2H_5OH, may be prepared by the fermentation of sugars. Prepare a mixture of 80 gm. of sucrose (cane sugar), 350 ml. water, and 35 ml. of Pasteur's salt. (**Prepare Pasteur's salt in the following manner:** dissolve 2 gm. K_2SO_4, 0.2 gm. $Ca_3(PO_4)_2$, 0.2 gm. $MgSO_4$, 10 gm. $(NH_4)_2C_4H_4O_6$ in 860 gm. water. This solution serves as a food upon which the yeast thrives.) To this mixture add one-half cake of yeast which has been ground in a mortar with water. The mixture should be placed in a 500 ml. flask or bottle and equipped with a one-holed rubber stopper and connected to a second flask as shown. The trap is used to exclude air from the mixture during fermentation. Why? Set the mixture away for several days or until fermentation ceases. Equation? When reaction has stopped distill over 60-70 ml. Put a few drops of the distillate



on a watch glass and ignite it. Appearance of the flame? Equation? Test 2 ml. of the distillate for the presence of ethyl alcohol as follows: (treat 2 ml. of bought ethyl alcohol in a separate test simultaneously.) To each liquid sample add a few crystals of solid iodine. After they are dissolved add a dilute solution of sodium hydroxide drop by drop until there is a decided color change. The color is due to iodoform, which may separate as a solid on standing. Note color. Equation? Is ethyl alcohol present in the distillate?

2. Aldehydes (336, 344)

Mix 3-4 ml. of methyl alcohol with an equal volume of water in a small test tube and place the tube in a beaker of cold water. Wrap a small copper wire around a pencil to make a spiral. Heat the spiral strongly until its surface is oxidized and plunge it into the alcohol while still hot. Repeat several times until there is a sharp and pungent odor from the tube. The odor is that of an aldehyde. Equation? The cupric oxide acts as an oxidizing agent (Meaning?) on the alcohol.

3. Acids (345)

Put about 20 gm. fused sodium acetate in a retort and cover with sulphuric acid. Heat the mixture and collect the acid which distills over. Equation if sodium acetate is $Na.C_2H_3O_2$. Color and smell of the acid. Dilute a little of the acid with 15 times its volume of water and taste. Result? Effect on litmus? Add some of the acid (1 to 3) to sodium bicarbonate. Result? Equation? Add a little of the acid to some alcohol in a test tube and then add a few drops of concentrated sulphuric acid. Heat gently. Smell? Equation?

4. Esters (345)

Esters are formed by the reaction of alcohols with acids. Mix 2 ml. each of ethyl alcohol and glacial acetic acid with a few drops of concentrated sulphuric acid (catalyzer. What is a catalyst?) Boil the mixture for about a minute. Carefully add solid sodium carbonate to the mixture to neutralize the acid. Warm the mixture and note the odor. Equation? Repeat the experiment by using iso-amyl alcohol in place of the ethyl alcohol. Describe the odor. Equation? Mix 0.3 gm. salicylic acid, 1 ml. methyl alcohol and 4-5 drops concentrated sulphuric acid. Warm gently and describe the odor. Equation? Repeat the test using ethyl alcohol in place of the methyl alcohol. Odor? Equation?

5. Ethers (345)

Ethers are compounds in which two radicals (not necessarily the same) are linked to an oxygen atom. The best known and most useful of the ethers is diethyl ether $(C_2H_5)_2O$: $CH_3CH_2OCH_2CH_3$ which is called simply "ether". It is prepared by removing the elements of water by concentrated sulphuric acid at about 140°. Add 10 drops of concentrated sulphuric acid to 3 ml. of 95 percent ethyl alcohol and warm cautiously. Note the odor. Equation? **(Note: add the acid to the alcohol.** Ether is partcularly dangerous because the vapor-air mixture is explosive and the density of the ether (2.5 times that of air) permits the explosive mixture to be carried as a convection current along the desk for several feet. **Do not make up a large "batch"** but use the quantities as given).

6. Soaps

Fats react with alkalies to form salts of the fatty acids. This process is called **saponification.** It is the procedure by which soap is made. Mix 5 ml. of cottonseed oil with 5 ml. of 6N NaOH in an evaporating dish. While stirring constantly, heat to boiling until a uniform solution is formed. Add enough water to bring the volume to about 25 ml. Add 10 gm. of NaCl solid to the mixture in a flask and shake well. The solid that separates is sodium oleate, a soap. Equation? Dissolve the soap in 15 ml. of water and shake. Lather? Repeat some of the steps in Laboratory Exercise 13 (6).

7. Rayon (Demonstration)

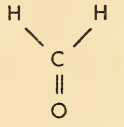
Rayon is a fibre made from regenerated cellulose. The process by which rayon is produced consists essentially in first dissolving the cellulose in a suitable solvent and reprecipitating it in the form of a fine thread. The cellulose of a spruce tree or a piece of paper may have its physical aspect so changed as to resemble a thread of cotton. Dissolve 25 gm. of $CuSO_4.5H_2O$ in 100 ml. of cold water. Add NH_4OH until action ceases. Equation? Filter and wash with cold water. Dissolve the precipitate in 100 ml. concentrated NH_4OH. Filter again. Shred a piece or two of filter paper and add to 50 ml. of the solution. Take some of this solution in a 25 ml. pipette. (**CARE.** Why?) place the end of the pipette just below the surface of 500 ml. 6N H_2SO_4 in a large beaker. Blow the solution rapidly into the acid. As soon as the solution strikes the acid, the ammonia of the cupric complex is neutralized and the cellulose is regenerated as a thread.

8. Perfume (Demonstration)

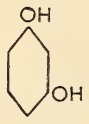
Heat 0.2 gm. beta-naphthol with 1 ml. of methyl alcohol and 5-6 drops of concentrated sulphuric acid in a test tube. The compound responsible for the odor is called jara-jara. Repeat with ethyl alcohol for the methyl alcohol. Can you describe the odors? Are they the same?

9. Polymer or Plastic (335) **(Demonstration)**

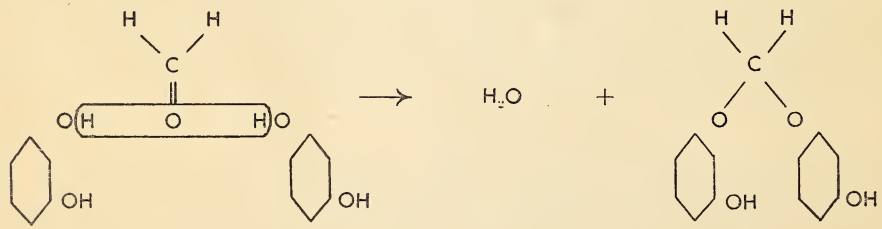
Put 2 gm. of resorcinol, 10 drops of 2M NaOH solution, and 2 ml. of formaldehyde in a test tube. Shake the mixture until solution is complete, and then heat in a water bath at 50°. If necessary to promote the reaction, raise the temperature to 70°. When the reaction appears to be complete, cool and break open the test tube and describe the nature of the polymer formed. The plastic formed by this reaction is quite typical of the phenol-formaldehyde resins or plastics. Resorcinol molecules, $C_6H_4(OH)_2$ are joined by $-CH_2$ groups supplied by the formaldehyde.



aldehyde



resorcinol



The oxygen of the formaldehyde takes hydrogen from each of two molecules of resorcinol. Cross linking makes a giant molecule or polymer. Try linking up about six molecules of resorcinol.

FOOD INGREDIENTS
STARCH; SUGAR; FATS; PROTEINS; MINERAL MATTER; BAKING SODA; BAKING POWDER

Laboratory Exercise 20

Reference: Text, Chapter 32, pages 347-359

1. **Starch**

Put a pinch of starch in a test tube and add water. Shake and boil. Cool under the tap and add a drop of iodine solution. Color? Test a freshly cut piece of potato and a piece of bread with the iodine solution, made by a crystal of iodine in potassium iodide solution.

2. **Sugar**

Dissolve 1 ml. of glucose in 10 ml. of water. Add 5 ml. of Fehling's solution and boil for a few minutes. The red precipitate formed shows the presence of glucose or fructose. Repeat using cane sugar (sucrose) solution. Result? Add a few drops of dilute hydrochloric acid to a sucrose solution. Bring to a boil then cool. Neutralize with powdered sodium carbonate. Now test with Fehling's solution. Result? What is inversion? Invert sugar? Equations?

3. **Fats and Oils**

Place a drop of oil on a piece of paper and hold it to the light. Result? Crush some walnuts or peanuts on a sheet of paper with the bowl of a spoon. Hold to the light. Result? Place some crushed peanuts in a test tube and add a little ether **(no flame nearby)** and shake. Allow to stand and then pour a few drops of the clear liquid on a piece of paper. Examine against the light. Result?

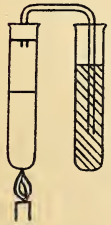
4. **Proteins**

Hard boil an egg and place a little of the white in a test tube. Add a few drops of concentrated nitric acid. Color? Did you ever spill a little concentrated nitric acid on your fingers? What is the yellow coloration? Recall Laboratory Exercise 14B.

5. **Mineral matter**

Place a teaspoonful of oatmeal in a crucible. Heat strongly in a hood until all the carbon is burned away. Result?

6. Test the following foods for **each** of the above. **Tabulate** your results. Bread — cheese — beans lean meat — cocoa.



7. **Baking Soda**

Sodium bicarbonate is a constituent of all baking powders and is therefore called baking soda.

(a) Put 2 gm. bicarbonate of soda in an arrangement as shown. Heat the bicarbonate gently. What is given off? Why does the lime water turn milky? Two equations.

(b) Set up as before, but instead of heat add a little dilute hydrochloric acid. Result? Equations?

(c) Sour milk contains lactic acid ($H.C_3H_5O_3$). Why is a mixture of sour milk and baking soda used as a leavening agent? Equation?

8. **Baking Powder**

Consists of some acid salt (dry) and sodium bicarbonate with some inert substance, such as starch or flour which is used to keep the acid salt dry and also used as a filler.

(a) Sprinkle a few particles of cream of tartar, potassium acid tartrate $KH(C_4H_4O_6)$, on a dry piece of litmus paper. Result? Wet. Result? Why?

(b) Use set-up as shown. Mix dry cream of tartar with dry baking soda. Add a little water. Stopper. Result? Equations? Other mixtures could be $NaHCO_3$ with NaH_2PO_4 : $NaAl(SO_4)_2$ or $CaHPO_4$ instead of $KHC_4H_4O_6$.

(c) Test several commercial baking powders. Result?

ANION ANALYSIS

Laboratory Exercise 21

The scheme outlined is for the identification of the following anions:

Group A: Carbonate (CO_3^{--}) Sulphite (SO_3^{--}) Sulphide (S^{--})

Group B: Chloride (Cl^-) Bromide (Br^-) Iodide (I^-)

Group C: Nitrate (NO_3^-)

Group D: Phosphate (PO_4^{---})

Group E: Sulphate (SO_4^{--})

Group F: Nitrite (NO_2^-)

A. To a portion of the original solution add **dilute HNO_3**. If no gas evolved pass on to group B. If gas evolved check as follows:

(1) If gas is colorless and odorless, test with lime water. If the lime water (on the end of a glass rod) goes milky then CO_2 is coming off and this indicates a **carbonate (CO_3^{--})** is present.

(2) If gas is colorless and has a sharp odor then SO_2 is evolved. Confirm by holding a drop of K_2CrO_4 on a glass rod in the gas. If the drop turns green SO_2 is evolved and this indicates a **sulphite (SO_3^{--})**.

(3) If gas is colorless and has the odor of rotten eggs, confirm by holding some filter paper soaked in lead acetate solution. The paper turns a shiny black. This indicates a **sulphide (S^{--})**.

B. To a portion of the original solution add $AgNO_3$ solution and HNO_3. If no precipitate pass on to the next group. If a ppt. is produced then:

(1) A white ppt. indicates a chloride. Confirm by adding NH_4OH in excess (moist red litmus). If ppt. dissolves this will indicate that a **chloride (Cl^-)** is present.

(2) A cream-colored ppt. indicates a bromide. Confirm by adding some MnO_2 and concentrated H_2SO_4 to the original if solid and heat. If a red-brown vapor comes off then a **Bromide (Br^-)** is present. Could also use unknown CCl_4, and chlorine water. Brown in CCl_4 layer.

(3) A yellow ppt. indicates an iodide. Confirm as above. If iodide is present the CCl_4 will be a violet color. The vapor with the MnO_2 and H_2SO_4 is a lilac or violet color. An **iodide (I^-)**.

C. To a portion of the original in a test tube add some **freshly** prepared ferrous sulphate and concentrated sulphuric acid (254). A brown ring between the two layers indicates a **nitrate (NO_3^-)**. Confirm by adding some copper turnings to a little concentrated H_2SO_4 to the original solution. Warm. Brown fumes. If no brown color then pass on to section D.

D. To about 2 cc. of ammonium molybdate in a test tube add about 1 ml. of the original solution to which has been added a little HNO_3. A fine yellow ppt. indicates a **phosphate (PO_4^{---})**. If no immediate reaction, warm a little. **Do not boil.** Allow to stand. If no yellow ppt. pass on to group E. Confirm by adding $AgNO_3$ to the original. A yellow ppt. soluble in HNO_3 or in NH_4OH indicates a phosphate.

E. To a portion of the original add $BaCl_2$ solution. Add dilute HCl. A white ppt. indicates a **sulphate (SO_4^{--})**. Confirm by boiling. The ppt. remains.

F. If the salt is insoluble in water treat as follows: Put a small quantity of the salt in a test tube and add a little concentrated sulphuric acid. Warm gently.

(a) If a colorless gas—identify as in Group A above, or if cloudy fumes are produced on breathing across the mouth of the test tube. This indicates a **chloride (Cl^-)**.

(b) If gas produced is brownish then the salt is a **nitrite (NO_2^-)**.

CATION ANALYSIS:

Laboratory Exercise 22

24

Na^+ K^+ NH_4^+ Mg^{++} Ca^{++} Fe^{+++} Fe^{++} Al^{+++} Cu^{++} Hg^{++} Pb^{++} Ag^+ Hg^+

Assume all substances are nitrates. Group 1 reagent, **DILUTE HCl,** is added in small amounts until no further ppt. forms. **FILTER.** Group I is **on** the filter paper and all the other chlorides, being soluble in an acid sol., are in the filtrate, containing Groups II, III & IV. **SAVE FILTRATE.**

Na^+ K^+ NH_4^+ Mg^{++} Ca^{++} Fe^{+++} Fe^{++} Al^{+++} Cu^{++} Hg^{++}

I

$PbCl_2\downarrow$ white xaline

$AgCl\downarrow$ white curdy

$HgCl\downarrow$ white dense

Group II reagent, **H_2S** is bubbled through the acidified filtrate from Gr. I. **FILTER.** Gr. II **on** the filter paper. Groups III & IV make the filtrate. **SAVE FILTRATE.**

Leave ppt. on filter paper. Wash well with **HOT WATER.** $PbCl_2$ is soluble & is in the filtrate. This separates Group I. Hg^+ & Ag^+ are on the filter paper.

Na^+ K^+ NH_4^+ Mg^{++} Ca^{++} Fe^{+++} Fe^{++} Al^{+++}

II

$CuS\downarrow$ black

$HgS\downarrow$ black

BOIL the filtrate to expell excess H_2S. Add some **NH_4Cl.** Add **NH OH** in slight excess (litmus). Group III on filter paper. The other hydroxides are sol. in basic solution and are in filtrate. **SAVE FILTRATE.**

A whitish ppt. of S from excess H_2S **or** if a sulphite is shown in anion tests.

$PbCl_2$ $AgCl\downarrow$ $HgCl\downarrow$

Divide filtrate into two parts

Pour small amount of dil. NH_4OH on the filter paper. AgCl dissolves to form the complex $Ag(NH_3)_2^+$ and the Ag^+ is now in filtrate. Hg^+ left on the filter paper as the black complex $Hg(NH_2)Cl\downarrow$

Na^+ K^+ NH_4^+ Mg^{++} Ca^{++}

III

$Al(OH)_3\downarrow$ white gelatinous

$Fe(OH)_2\downarrow$ greenish

$Fe(OH)_3\downarrow$ rusty

$CuS\downarrow$

$HgS\downarrow$

Boil in dilute HNO_3 & Filter

H_2SO_4

K_2CrO_4

We use no procedure for separating the members of Group IV. Use small portions of the alkaline sol. **or** the original, as shown.

The procedure to separate the members is too complicated. Depend on the nature of ppt. & color of original sol.

– $Hg\downarrow$ + $Hg(NH_2)Cl\downarrow$ ---------- Hg^{+}

– $Ag(NH_3)_2^{+}$ – Add HNO_3 to filtrate — $AgCl\downarrow$ white curdy — allow to stand in sunlight: turns purple ---------- Ag^{+}

– $PbSO_4\downarrow$ white (not very good test)
– $PbCrO_4\downarrow$ yellow, fine, compact
---------- Pb^{++}

$HgS\downarrow$ — Confirm by adding freshly prep. stannous chloride to the original — a grey or black ppt. ---------- Hg^{++}

Cu^{++} — **NH_4OH in excess or** to the original add potassium ferrocyanide ..... $Cu(NH_3)_4^{++}$
deep blue
choc. ppt.
---------- Cu^{++}

$Al(OH)_3\downarrow$ — Charcoal block — Some of the ppt. Heat with blow pipe — Add drop $Co(NO_3)_2$ — HEAT AGAIN blue mass ---------- Al^{+++}

$Fe(OH)_2\downarrow$ — Use some of the **original.**
Color ----------
NH_4CNS ---------- No color change
$K_3Fe(CN)_6$ ---------- Turnbull's blue
---------- Fe^{++}

$Fe(OH)_3\downarrow$ — Use some of the **original.**
Color ----------
NH_4CNS ---------- Blood red
$K_4Fe(CN)_6$ ---------- Prussian blue
---------- Fe^{+++}

IV

Some of the alkaline sol. — $(NH_4)_2CO_3$ — $CaCO\downarrow$ white — Confirm by FLAME TEST — Orange-red ---- Ca^{++}

Some of the alkaline sol. — $(NH_4)_2CO_3$ **Filter** — to this filtrate add Na_2HPO_4 — $MgNH_4PO_4\downarrow$ — White Xaline ----- Mg^{++}

Some of the **original** sol. — Boil to ½ vol. Add NaOH and Heat — smell for $NH_3\uparrow$ or use moist red litmus ---------- NH_4^{+}

Some of the **original** sol. — FLAME TEST — lilac flame — Cobalt glass if Na^{+} present ---------- K^{+}

Some of the **original** sol. — FLAME TEST — strong yellow flame ---------- Na^{+}

APPENDIX

SUPPLIES FOR SIX STUDENTS

The following is a list of the supplies needed for six students working in three groups of two each or for three students working singly. A reasonable margin has been allowed for breakages. The list is divided under sub-headings as follows:

A. Apparatus required for all groups. It is desirable that this be issued at the beginning of the year, especially if drawers and cupboards lock.

B. (1) Apparatus for common use of several groups. This should be considered a minimum list.

(2) Additional and more extensive apparatus which should be included for large classes or even for small ones if circumstances permit.

C. Chemicals.

D. Materials which may be obtained locally.

A. — Apparatus required for all groups

(Quantities are sufficent for three groups.)

Note: "Pyrex" or some good resistance glass is recommended for all glassware. Although it is more expensive, it is so much more durable that its use results in greater economy.

DESCRIPTION	QUANTITY
Alcohol lamps, 4 oz. at least (or Bunsen burners with the fish tail attachment if gas is available)	3
Beakers, low form with lip, 250 cc	6
Beakers, low form with lip, 150 cc.	6
Blowpipes, 8-10 inches, brass recommended	3
Blue Glasses, 2"x1"	3
Bottles for collection of gases, etc., at least 8 oz., low form	12
Bottles for reagents, glass stoppers, at least 4 oz.	30
Burettes, 50 cc., Mohr type for pinchcock recommended	3
Burette, fittings for above, burette tip with rubber tubing and pinchcock	3
Filter papers, 5" dia., coarse for rapid work	1 pkg
Flasks, Erlenmeyer, 300 cc., No. 6 top	4
Rubber stopper, two holes, No. 6 for the above flasks	4
Funnels, glass, 65 mm. dia., 150 mm. stem	3
Glass tubing, 6 mm. ext. dia.	⅛ lb.
Graduates, 100 cc. to show 1 cc.	3
Graduates, 10 cc.	3
Noncombustible rods for flame tests (or see B list)	3
Pipettes, 10 cc., (note: 3 burettes may be used instead)	1
Pneumatic troughs, galvanized iron or glass, about 7"x10"x5"	3
Retorts, 125 to 250 cc., glass for making bromine	3
Retort stands, base, about 3½"x6½"	3
Retort stands, rings—large 3¼" dia. inside; small, 2½" dia.	3 each
Retort stands, fixtures, burette clamp	3
Rubber tubing, 3/16" dia. inside for generators and connections	8 ft.
Test tubes, 16 mm. dia. outside, 150 mm. long	30
Test tubes, 20 mm. dia. outside, 150 mm. long (prep. of O_2)	5
Rubber stoppers, 1 hole, size No. 2, large end, 20 mm.	3
Test tube brush, bristle end	3
Test tube racks, large enough to hold 10 tubes upright rec.	3
Thistle tube, stem, 6 mm. dia. outside	4
Tubes, combustion, dia. inside about 15 mm., length 5-12"	3
Wire gauze squares, iron or copper, 4" side	3

B. — (1) Apparatus for the common use of several groups

DESCRIPTION	QUANTITY
Balance, with weights, capacity 100 to 150 grams, sensitivity 5 mg. (Note: If balance is to be used for Physics 30 as well one of greater capacity should be obtained)	1
Bottles, reagent, glass stoppers, 500 cc. capacity	10
Beaker, low form with lip, pyrex, capacity 600 cc.	1
Barometer, graduated in Metric scale, aneroid is recommended	1
Files, triangular, 5"	3
Funnel, glass, dia. at least 80-100 mm.	1
Mortar and pestle, about 5" dia.	1
Thermometer, Centigrade, range —10° — 110°, solid stem	1
Platinum wire, length 3" long sealed in glass tubing	6 in.
Flask, Erlenmeyer, 500 cc., with generator fittings if Kipp's Apparatus is not available (See below)	1

Furniture: (1) Tables for students' practical work in the laboratory. Suggestions re construction: height, 36 in.; width 4 ft.; length, depends on the requirements and space available. Each group needs a space about four feet wide and half the width of the table; this gives about eight square feet. A shelf along the center of the table is convenient for reagent bottles. Drawer and cupboard space for storing apparatus in students' tables is needed. If they are constructed with locks, groups may be given sets of apparatus at the beginning of the year and held responsible for it throughout the year. (2) Cupboards, which will lock, are needed for storing chemicals and apparatus. (3) Demonstration table for instructor, specifications, see above, width 2½ to 4 ft.

B. — (2) Additional and more extensive apparatus which should be included for large classes

Kipp's gas generator, capacity of generating chamber, 500 cc.

Fume cupboard: As poisonous gases are very injurious for students and teacher, a fume cupboard for the preparation of such gases should be provided. Position, near demonstration table in the classroom so that it may be used conveniently during instruction periods, as well as during laboratory periods.

Size, at least two feet square; bottom of cupboard 3 feet from floor; height about 3½ feet, that is, top 6½ feet from the floor.

Ventilation: If poisonous gases are to be prevented from entering the room, this cupboard should be connected to the outside of the building by means of a pipe. If it is not feasible to do this through the heating or ventilating systems of the building, an electric fan may be found to be effective.

NOTE: Large classes will require additional quantities of the apparatus listed under B (1) above.

C. — Chemicals

Acetic Acid (glacial)
Alcohol (for use in lamps)
Alcohol, ethyl (denatured) 95%
Alcohol, methyl
Alum, pure powder
Aluminium foil and turnings
Aluminium Chloride C.P.
Aluminium Nitrate C.P.
Aluminium Sulphate C.P.
Ammonium Acetate, 4 oz.
Ammonium Carbonate C.P.
Ammonium Chloride C.P.
Ammonium Hydroxide C.P.
Ammonium Nitrate C.P.
Ammonium Molybdate C.P.
Ammonium Sulphate C.P.
Ammonium Sulphide Solution
Ammonium Phosphate C.P.
Ammonium Tartrate
Ammonium Thiocyanate C.P.
Antimony powder
Antimony Trichloride
Arsenic Trichloride
Arsenious Oxide (Demon. only)

Barium Chloride C.P.
Barium Nitrate C.P.
Beta-Naphthol
Bismuth Trichloride
Bleaching Powder
Borax, Crystals

Calcium Carbonate, ppt.
Calcium Carbonate, marble chips
Calcium Chloride C.P.
Calcium Fluoride
Calcium Hydroxide, Tech.
Calcium Nitrate C.P.
Calcium Oxide
Calcium Phosphate
Calcium Sulphate
Carbon, activated
Carbon Disulphide
Carbon Tetrachloride
Charcoal, animal, powder
Charcoal, blocks
Chromium Nitrate, 2 oz.
Cobalt Nitrate
Copper filings
Copper Chloride, 2 oz.
Copper Oxide, 2 oz.
Copper wire, heavy, insulated 10'
Cottonseed oil
Cupric Bromide
Cupric Nitrate C.P.
Cupric Sulphate C.P., pow.
Cupric Sulphate, Tech.
Cupric Chloride, C.P.
Cupric Sulphide

Fehling's solution
Ferric Chloride, C.P.
Ferric Nitrate, C.P.
Ferric Sulphate, C.P.
Ferrous Chloride, C.P.
Ferrous Sulphate
Ferrous Sulphide, sticks
Formaldehyde
Formic Acid

Glucose, pure anhydrous

Hydrochloric Acid, C.P.

Iodine Xals
Iron filings (fine)

Lead Acetate, 8 oz.
Lead Nitrate, C.P.
Lead Sulphide
Lead Oxide (litharge)
Lithium Chloride
Lithium Nitrate, 1 oz.
Litmus, Best qual., gran.
Litmus paper, blue, vial of 100 strips.
Litmus paper, red
Logwood

Magnesium powder
Magnesium ribbon
Magnesium Carbonate, heavy
Magnesium Chloride, C.P.
Magnesium Nitrate, C.P.
Magnesium Sulphate, C.P.
Manganese Dioxide, Tech.
Mercuric Chloride, C.P.
Mercuric Nitrate, C.P.
Mercuric Sulphide
Mercurous Nitrate, C.P.
Mercury metal
Methyl Orange
Methyl Violet

Nitric Acid, C.P.

Phenolphthalein
Phosphoric Acid
Phosphorus, yellow
Plaster of Paris
Potassium Bromide, C.C. or U.S.P.
Potassium Carbonate, C.P.
Potassium Chlorate, C.P., pow.
Potassium Chloride, C.P.
Potassium Chromate, C.P.
Potassium Ferricyanide, C.P.
Potassium Ferrocyanide, C.P.
Potassium Hydroxide (pellets), 4 oz.
Potassium Iodide
Potassium metal
Potassium Nitrate, C.P.
Potassium Permanganate, U.S.P.
Potassium Phosphate, C.P.
Potassium Sulphate, C.P.
Potassium Sulphite, C.P.

Resorcinol
Roll sulphur and Flowers of sulphur

Silver Nitrate
Sodium Acetate anhy.
Sodium Bicarbonate, C.P.
Sodium Bisulphite
Sodium Borate (Borax), 2 oz.
Sodium Bromide
Sodium Carbonate, Tech., pow.
Sodium Chloride, C.P.
Sodium Hydroxide, C.C. sticks or pellets
Sodium Iodide
Sodium metal
Sodium Nitrate, C.P., pow.
Sodium Peroxide, pow.
Sodium (Disodium) Phosphate, C.P.
Sodium Sulphate, C.P.
Sodium Sulphite, C.P.
Sodium Thiosulphate
Starch, corn (soluble)
Strontium Chloride, C.P.
Sulphuric Acid, C.P.

Zinc, C.P. (low in As.), gran.
Zinc Chloride, C.P.
Zinc Nitrate, C.P.
Zinc Oxide
Zinc Sulphate, C.P.
Zinc Sulphide, Tech.

NOTE: The above list includes a variety of salts which may be used as "unknowns" in Laboratory Exercises 23 and 24.
Equivalents: 28.3 grams = 1 oz.; 1 pound = 453.6 grams.

D — Materials which may be obtained locally

(For class of six, three groups)

DESCRIPTION	QUANTITY
Baking Soda	
Candles, paraffin, for demonstration	2
Clay, well pulverized	¼ lb.
Clock spring, ⅛" wide	1 ft.
Commercial soap, 3 or 4 cakes	
Copper sheet, medium gauge, 17 sq. in. cut into strips about 3"x⅜"	
Distilled water	½ gal.
Finger bandaging 2" wide	1 yd.
Glass (window) cut in 3" squares	6 sqs.
Gun Squares for 22's	1 pkg.
Honey	1 oz.
Iron nails, bright, 1½-2"	6
Kerosene	
Lard or other fat	
Lime (quicklime)	
Liquid soap	
Molasses, black	2 oz.
Oatmeal	1 oz.
Paraffin candle wax	4 oz.
Red calico	⅛ yd.
Steel wool	
Sugar, brown, cane or beet	28 gm.
Turpentine	
Vaseline	
Vegetable oil (olive, peanut, etc.)	1 oz.
Vinegar	1 oz.
Washing soda crystals	4 oz.
Wire gauze	
Wooden splints 6"-8" long	2 doz.
Yeast cakes	

SOLUTIONS

See the general rules for solubility as given in the text on pages 371-2.

There are two methods of making up solutions. We frequently use the **weight** of the acid, base or salt used in making up **one litre of the solution.** If the litre of solution contains one gram molecular weight it is called a molar solution. For example a molar (M) solution of hydrochloric acid contains 36.5 grams in one litre of the solution. A molar solution of sodium hydroxide contains 40 grams, of common salt there is 58.5 grams. In making the solution weigh out a quantity as represented by the molecular formula and add enough water to make a solution. Now continue to add water until the total volume comes to 1,000 ml. or **a litre of the solution.** Decimal fractions are used in referring to molar (M) solutions. If 10 gm. of NaOH are used per litre of solution it is a 0.25M solution. 37 gm. of $Ca(OH)_2$ per litre of solution is a 0.5M solution.

The other method of naming and making solutions depends upon **the definitions of normality.** By definition, if 1 gm. of replaceable hydrogen per litre of solution is used, then the solution is a one normal (1N) solution. Similarly, by definition, if 17 gm. of the hydroxyl group are used in making 1 litre of solution, then the solution is a one normal (1N) solution. In like manner one litre of a salt solution that contains the equivalent of 1 gm. of replaceable hydrogen is a normal salt solution. 36.5 gm. HCl acid in a litre of solution is a 1 molar as well as a 1 normal solution. If 98 gm. H_2SO_4 acid were used in making a litre of solution the solution is called a 1M or a 2N solution. A molar solution of $Ca(OH)_2$ is a 2 normal. A normal solution of aluminium chloride, $AlCl_3$, contains 44.5 gm. per litre of solution. A molar solution of $AlCl_3$ is a 3N solution.

Knowing the molarity or the normality of the common reagents bought in the 2 litre bottles, it should be easy to make up solutions of any desired strength. Various strengths are suggested if one wishes to set up a series of solutions for ready use.

Name	Formula	Concentration	Could Make Up
Acetic, glacial	$HC_2H_3O_2$	17.4M	6N, 1N, 0.1M
Hydrochloric, con.	HCl	12M	6N, 1N, 0.1M, 0.5N
Nitric, conc.	HNO_3	16N	6N, 0.1M
Phosphoric, conc. 85%	H_3PO_4	15M	1N, 0.1M
Sulphuric, conc.	H_2SO_4	18M	6N, 1N, 0.1N
Ammonium hydroxide, conc.	NH_4OH	15M	6N, 1N, 0.1M

PREPARATION OF INDICATORS:

Methyl orange: Dissolve 1.0 gm. in 1000 ml. of water.

Methyl violet: Dissolve 0.5 gm. in 1000 ml. of water.

Phenolphthalein: Dissolve 1 gm. in 700 ml. of 95% C_2H_5OH and dilute to 1000 ml. with water.

Methyl orange paper: Dip large sheets of filter paper into 0.2 gm./L of water solution. Hang up to dry. Cut 1 cm. x 4 cm. strips.

Potassium iodide—starch paper: To 1000 ml. boiling water add 5 gm. of starch and 10 gm. of KI. Dip large sheets of filter paper into hot solution. Hang up to dry. Cut into strips.

Starch paper: Dissolve 5 gm. of starch in 1000 ml. boiling water. Dip large sheets of filter paper into the hot solution. Hang up to dry. Cut into strips.

LIQUID REAGENTS

Acetic acid (dil.)	6N	350 cc. glacial $HC_2H_3O_2$, 650 cc. H_2O.
Albumen solution	0.5%	5 gm. egg albumen, 1000 cc. cold water, stir until dissolved. Filter.
Alizarin	0.01%	0.1 gm. alizarin, 1000 cc. 95% C_2H_5OH.
Aluminium sulphate	1.8N	200 gm. $Al_2(SO_4)_3.18H_2O$, 1000 cc. H_2O.
Ammonium carbonate	3N	144 gm. $(NH_4)_2CO_3$, 1000 cc. 6N NH_4OH.
Ammonium chloride	2N	107 gm. NH_4Cl, 1000 cc. H_2O.
Ammonium hydroxide (dil.)	6N	400 cc. conc. NH_4OH, 600 cc. H_2O.
Ammonium molybdate	N	88.3 gm. $(NH_4)_6Mo_7O_{24}.4H_2O$, 100 cc. 6N NH_4OH, 240 gm. NH_4NO_3, dilute to 1000 cc. with H_2O.
Ammonium Nitrate	N	80 gm. NH_4NO_3, 1000 cc. H_2O.
Ammonium polysulphide		Saturate 150 cc. conc. NH_4OH with H_2S, add 250 cc. conc. NH_4OH, add 10 gm. sulphur, when all S dissolved add 600 cc. H_2O. Filter.
Arsenic trichloride	0.6N	20 gm. As_2O_3, 120 cc. conc. HCl, warm until dissolved, add 880 cc. H_2O.
Barium chloride	N	122 gm. $BaCl_2.2H_2O$, 1000 cc. H_2O.
Bismuth nitrate	1.5N	243 gm. $Bi(NO_3)_3.5H_2O$, 50 cc. conc. HNO_3, 950 cc. H_2O.
Calcium hydroxide	sat'd.	Shake fresh lime with water. Filter.
Calcium sulphate	sat'd.	1000 cc. H_2O, 6 cc. 6N H_2SO_4, 2 gm. pptd. $CaCO_3$, shake: let stand 1 hour, soln. must be neutral to litmus or show undissolved $CaCO_3$. Filter.
Chlorine water	sat'd.	Saturate H_2O with chlorine gas, keep in amber bottle.
Cobalt nitrate	0.4N	58 gm. $Co(NO_3)_2.6H_2O$, 1000 cc. H_2O.
Copper nitrate	0.4N	59 gm. $Cu(NO_3)_2.6H_2O$, 1000 cc. H_2O.
Ferric nitrate	0.6N	80 gm. $Fe(NO_3)_3.9H_2O$, 20 cc. 6N HNO_3, 980 cc. H_2O.
Ferrous sulphate	2N	392 gm. $Fe(NH_4)_2(SO_4)_2.6H_2O$, 500 cc. 6N H_2SO_4, 500 cc. H_2O.
Hyrdochloric acid (dil.)	6N	500 cc. conc. HCl, 500 cc. H_2O.
Iodine solution	sat'd.	add excess powdered I_2 to water.
Lead nitrate	N	165 gm. $Pb(NO_3)_2$, 1000 cc. H_2O.
Magnesium nitrate	N	130 gm. $Mg(NO_3)_2.6H_2O$, 1000 cc. H_2O.
Mercuric chloride	0.4N	54 gm. $HgCl_2$, 1000 cc. H_2O.
Mercurous nitrate	0.5N	140 gm. $HgNO_3.H_2O$, 20 gm. Hg, 50 cc. conc. HNO_3, 950 cc. H_2O.
Nitric acid (dil.)	6N	380 cc. conc. HNO_3, 620 cc. H_2O.
Potassium chloride	N	75 gm. KCl, 1000 cc. H_2O.

Potassium chromate	2N	194 gm. K_2CrO_4, 1000 cc. H_2O.
Potassium ferricyanide	0.9N	100 gm. $K_4Fe(CN)_6$, 100 cc. H_2O.
Potassium ferrocyanide	N	105 gm. $K_4Fe(CN)_6.3H_2O$, 1000 cc. H_2O.
Potassium permanganate	0.1M	16 gm. $KMnO_4$, 1000 cc. H_2O.
Silver nitrate	0.1N	17 gm. $AgNO_3$, 1000 cc. H_2O.
Soap solution	10%	Dissolve 100 gm. sodium oleate in 842 cc. 95% C_2H_5OH, add 158 cc. H_2O. Filter.
Sodium acetate	3N	408 gm. $NaC_2H_3O_2.3H_2O$ **or** 246 gm. $NaC_2H_3O_2$, 1000 cc. hot water.
Sodium carbonate	2N	106 gm. anhyd. Na_2CO_3 or 124 gm. $Na_2CO_3.H_2O$, or 286 gm. $Na_2CO_3.10H_2O$, 1000 cc. H_2O.
Sodium chloride	N	58.5 gm. NaCl, 1000 cc. H_2O.
Sodium hydroxide	2.5N	100 gm. NaOH (tech)., 1000 cc. H_2O.
Sodium phosphate (disodium)	0.75N	90 gm. $Na_2HPO_4.12H_2O$, 1000 cc. H_2O.
Sodium sulphate	N	161 gm. $Na_2SO_4.10H_2O$, 1000 cc. H_2O.
Stannic chloride	0.5N	33 gm. $SnCl_4$ liquid, **or** 40 gm. $SnCl_4.3H_2O$, **or** 44 gm. $SnCl_4.5H_2O$, 100 cc. conc. HCl, 900 cc. H_2O.
Stannous chloride	0.5N	58 gm. $SnCl_2.2H_2O$, 100 cc. conc. HCl, 900 cc. H_2O, add granulated tin.
Strontium nitrate	N	142 gm. $Sr(NO_3)_2.4H_2O$, 1000 cc. H_2O.
Sulphuric acid (dil.)	6N	200 cc. conc. H_2SO_4, 1000 cc. H_2O.
Zinc nitrate	0.5N	89 gm. $Zn(NO_3)_2.6H_2O$, 1000 cc. H_2O.

YAMADA'S UNIVERSAL INDICATOR

Thymol blue	.005 gram
Methyl red	.0125 gram
Bromthymol blue	.06 gram
Phenolphthalein	.1 gram

Dissolve the dyes in 100 cc. of 95% ethyl alcohol. Neutralize (to green color) with .05 molar sodium hydroxide solution. Make up 200 cc. with distilled water.

pH Values for Color Changes in Yamada's Universal Indicator

pH	Color	pH	Color
4	red	8	blue
5	orange	9	indigo
6	yellow	10	violet
7	green	11, 12	deep violet

SOLUBILITY

+ ion ↓	Negative Radical																						
	Acetate	*Arsenate*	*Arsenite*	*Borate*	*Bromide*	*Carbonate*	*Chlorate*	*Chloride*	*Chromate*	*Cyanide*	*Ferricyanide*	*Ferrocyanide*	*Fluoride*	*Hydroxide*	*Iodide*	*Nitrate*	*Oxalate*	*Oxide*	*Phosphate*	*Silicate*	*Sulfate*	*Sulfide*	*Tartrate*
Al	W	a	—	A	W	—	W	W	—	—	—	w	I	A	W	W	A	A	A	a	W	A	W
NH_4	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	—	W	—	W	W	W
Sb	—	a	A	—	w	—	—	w	A	—	—	—	W	—	w	—	A	A	w	—	w	A	A
Ba	W	A	A	A	W	A	W	W	A	w	w	w	a	W	W	W	A	W	A	A	I	W	A
Bi	W	A	—	A	w	A	W	w	A	w	—	w	A	A	A	W	A	A	A	—	W	A	A
Cd	W	A	—	w	W	A	W	W	A	A	A	—	w	A	W	W	A	A	A	A	W	A	w
Ca	W	A	A	w	W	A	W	W	w	W	W	W	a	w	W	W	A	w	A	A	A	W	A
Cr	W	A	—	A	W	—	W	W	A	A	—	—	W	A	W	W	w	A	A	A	W	A	W
Co	W	A	A	A	W	A	W	W	A	a	I	I	w	A	W	W	A	A	A	A	W	A	W
Cu	W	A	A	W	W	A	W	W	W	A	I	I	A	A	W	W	A	A	A	A	W	A	W
Fe^{++}	W	A	A	A	W	A	W	W	—	a	I	I	w	A	W	W	A	A	A	A	W	A	w
Fe^{+++}	W	A	A	A	W	—	W	W	W	—	W	I	W	A	W	W	A	A	A	A	W	A	W
Pb	W	A	A	A	a	A	W	a	a	A	w	A	A	A	w	W	A	A	A	A	a	A	A
Mg	W	A	A	w	W	A	W	W	W	W	W	W	a	A	W	W	A	A	A	A	W	A	W
Mn	W	A	A	A	W	A	W	W	W	W	I	A	A	A	W	W	w	A	A	A	W	A	W
Hg^{+}	w	A	A	—	a	A	W	a	A	A	—	—	W	—	A	W	A	A	A	—	w	A	w
Hg^{++}	W	A	A	—	W	A	W	W	w	A	A	A	w	—	A	W	A	A	A	—	w	A	w
Ni	W	A	A	A	W	A	W	W	A	a	I	I	w	A	W	W	A	A	A	A	W	A	A
K	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Ag	w	A	A	A	I	A	W	I	A	I	I	I	W	—	I	W	A	A	A	—	w	A	A
Na	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Sn^{++++}	W	A	—	—	W	—	—	W	—	—	—	I	W	A	W	w	W	A	A	—	W	A	—
Sn^{++}	W	A	A	A	W	—	W	W	A	—	—	I	W	A	W	—	A	A	A	—	W	A	A
Zn	W	A	A	A	W	A	W	W	W	A	A	I	w	A	W	W	A	A	A	A	W	A	A

Key: *W*, soluble in water; *A*, soluble in acids, not in water; *w*, slightly soluble in water, soluble in acids; *a*, slightly soluble in acids, insoluble in water; *I*, insoluble in both water and acids.

GENERAL SOLUBILITY RULES

The following are *soluble* in water:

1. All sodium, potassium, and ammonium compounds

2. All nitrates, chlorates, and acetates

3. All chlorides *except* those of silver, mercury (Hg^{+}), copper (Cu^{+}), and lead (lead chloride is slightly soluble)

4. All sulfates *except* those of lead, barium, strontium, and calcium (silver and mercurous sulfates are only fairly soluble)

The following are *insoluble* in water:

1. All carbonates *except* those of sodium, potassium, and ammonia

2. All oxides (except BaO and CaO, which are slightly soluble)

3. All hydroxides *except* those of sodium, potassium, ammonia, barium and calcium (calcium hydroxide is only slightly soluble)

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